This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

B 429669 DUPL

GENERAL LIBRARY
OF
UNIVERSITY OF MICHIGAN

PRESENTED BY
The Commissioner
24 Nov. 1893

TN
913
.U58
A23
1893

SIXTH SPECIAL REPORT

OF THE

From

COMMISSIONER OF LABOR.

Nov. 24, 93

THE

PHOSPHATE INDUSTRY

OF THE

UNITED STATES.

PREPARED IN COMPLIANCE WITH A RESOLUTION OF THE UNITED STATES
SENATE OF DECEMBER 4, 1890,

BY

CARROLL D. WRIGHT,
COMMISSIONER OF LABOR.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1893.

SIXTH SPECIAL REPORT

From

OF THE

COMMISSIONER OF LABOR.

Nov. 24, 93

THE PHOSPHATE INDUSTRY OF THE UNITED STATES.

PREPARED IN COMPLIANCE WITH A RESOLUTION OF THE UNITED STATES SENATE OF DECEMBER 4, 1890,

BY

CARROLL D. WRIGHT,
COMMISSIONER OF LABOR.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1893.

U.S. Bureau of Labor.

SIXTH SPECIAL REPORT
OF THE
COMMISSIONER OF LABOR.

49

THE
PHOSPHATE INDUSTRY
OF THE
UNITED STATES.

PREPARED IN COMPLIANCE WITH A RESOLUTION OF THE UNITED STATES SENATE OF DECEMBER 4, 1890,

BY

CARROLL D. WRIGHT,
COMMISSIONER OF LABOR.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1893.

CONTENTS.

Page.
LETTER OF TRANSMITTAL 5, 6
INTRODUCTION 7-19
CHAPTER I.—THE PHOSPHATE INDUSTRY OF FLORIDA 21-69
  Geology of the phosphate fields of Florida 23-31
  Geographical position of the Florida phosphate belt 31-34
  Topography of the Florida phosphate belt 34, 35
  Discovery of phosphate in Florida 36-39
  Comparative merits of the hard rock and pebble belts 40
  Estimated phosphate in sight in Florida 40-42
  Kinds of phosphate, machinery used, etc 42-66
    Hard rock 42-50
    Gravel screenings 50, 51
    Plate rock 51-54
    Composite phosphate 54, 55
    Soft phosphate 55-58
    Land pebble 58-61
    River pebble 61-65
    A geological wonder 65, 66
  General observations 66-69
CHAPTER II.—THE PHOSPHATE INDUSTRY OF SOUTH CAROLINA 71-86
  Geology of the phosphate fields of South Carolina 73-77
    Names given to the phosphate rocks 73, 74
    Age of the phosphate basins of the Ashley 74
    Recent or Historic age 74, 75
    Origin of the phosphate rocks 75, 76
    What are fossils and petrifactions 76, 77
    The fish-bed of the Ashley 77
  Discovery of phosphate in South Carolina 77-82
  Kinds of phosphate, machinery used, etc 83-85
    Land and river rock 83
    Land mining 83, 84
    River phosphate 84
    Hand picking 84
    Dredging 84
    Machinery for loading and discharging 84
    Crushing and washing 84, 85
  Analyses 85, 86
CHAPTER III.—GENERAL STATISTICS OF THE PHOSPHATE INDUSTRY 87-137
  The cost of production 92-96
  The shipment and consumption of phosphate 96-102
  The commercial aspect 102-105
  Royalties 105
  The opportunities for labor 106-108

5-20-38

Page
CHAPTER III.—GENERAL STATISTICS OF THE PHOSPHATE INDUSTRY—Con'd.
General tables 108-137
Table I.—Cost of production of phosphate in the United States, 1890-1892—land mines 110-131
A.—Period covered and quantity of product 110, 111
B.—General description, capital invested, etc 112, 113
C.—Distance, means, and cost of transportation 114, 115
D.—General statement of cost for the period 116, 117
E.—Elements of cost in one ton of 2,240 pounds 118, 119
F.—Per cent. of each element of cost in one ton of 2,240 pounds 120, 121
G.—Additional cost of certain theoretical elements for the period 122, 123
H.—Additional cost of certain theoretical elements in one ton of 2,240 pounds 124, 125
J.—Rates of wages 126-131
Table II.—Cost of production of phosphate in the United States, 1890-1892—river mines 132-137
A.—Period covered and quantity of product 132
B.—General description, capital invested, etc 132
C.—Distance, means, and cost of transportation 133
D.—General statement of cost for the period 133
E.—Elements of cost in one ton of 2,240 pounds 134
F.—Per cent. of each element of cost in one ton of 2,240 pounds 134
G.—Additional cost of certain theoretical elements for the period 135
H.—Additional cost of certain theoretical elements in one ton of 2,240 pounds 135
J.—Rates of wages 136, 137

LETTER OF TRANSMITTAL.

DEPARTMENT OF LABOR,
Washington, D. C., March 20, 1893.

SIR: I have the honor to hand you herewith a special report relating to the phosphate industry of the United States.

This report has been prepared in compliance with the following resolution of the Senate:

> IN THE SENATE OF THE UNITED STATES,
> *December 4, 1890.*
>
> *Resolved,* That the Commissioner of Labor is hereby directed to examine and report the extent of the phosphate industry in the United States, the number of laborers employed, and the opportunities for the employment of labor in the future development of the phosphate deposits.

The obstacles in the way of securing full information have resulted in many delays in answering the above resolution. At the date of its passage the phosphate industry had not been developed to such an extent in the state of Florida as to warrant very complete statistical information, while in South Carolina the industry had become settled and the conditions well known. The first attempts, therefore, to collect classified data relating to the industry were not particularly satisfactory. Many establishments were getting into working order, while others were closing up. A delay was thus unavoidable, but the delay resulted in far more complete information than could have been secured at an earlier date. As it is, this report practically brings the facts relating to the industry down to the first day of January of the present year. No effort has been made to follow along lines of other official reports, yet such reports have been most carefully studied for the purpose of corroboration and the avoidance of errors. It is true, however, that no other official report has taken up the industry in accordance with the exhaustive plans adopted by the Department under the resolution of the Senate.

Many of the establishments comprehended in this report have been visited several times for the purpose of gaining complete information. All the facts relating to the cost of production, mining, wages, labor, etc., have been secured either at the works themselves or at the offices of the companies managing them. Notwithstanding all this care, there are many omissions, but all such omissions are the result of the impossibility of securing fairly accurate information. On the whole, the report is quite full and comprehensive, and may be relied upon as trustworthy.

The chief material, both for the text and for the statistical part of this report, has been collected by Capt. James F. Tucker, a special agent of this Department. He has been assisted at times by Messrs. Britton, Buffington, Smith, Colquitt, Taliaferro, and Durham. The tabulations have been in charge of Mr. G. W. W. Hanger, chief of the tabulation division of the Department, and I desire to acknowledge Mr. Hanger's services and those of Mr. Weaver, the chief clerk of the Department, in the preparation of this report.

I am, very respectfully, your obedient servant,

CARROLL D. WRIGHT,
Commissioner.

The PRESIDENT OF THE SENATE.

INTRODUCTION.

INTRODUCTION.

The phosphate industry of the United States is located in the states of North Carolina, South Carolina, Florida, and Georgia. Some mines have been opened in other parts of the United States, but they are not in operation to a sufficient extent to warrant their having a place in this report, which covers 30 establishments in South Carolina, 1 in North Carolina, and 106 in Florida, or a total of 137 phosphate mining establishments.

The Engineering and Mining Journal, in its issue of October 3, 1891, in speaking of the phosphate industry of the United States, used the following language:

> There is no exaggeration in the statement that few discoveries of our time have attracted more general attention than those incalculably vast phosphate deposits of our Southern states, promising, as they do, to confer upon us as a nation the preponderating influence over the entire fertilizer market.

The facts collected for this report prove conclusively the truth of this statement, for the proportions of the growing industry are brought into recognized prominence. This industry is of recent establishment. Though the discovery of phosphate in South Carolina was made prior to the year 1867–'68, it was not until this date that the importance and value of the discovery was recognized and appreciated by scientific and business men. Following closely upon this recognition, enterprise and capital laid the foundation of the present great phosphate mining industry, and within a very few years its growth was so marked as to exercise great influence over the mineral phosphate market of the world. The industry at that time was but a quarter of a century old. The South Carolina phosphates, from their superior merits, have continued to grow in public favor, a statement which is proved by the steady increase in the annual demand. In 1868 the South Carolina mines produced 11,862 tons, while in 1891 they produced 572,949 tons. Mr. Hermann Voss, an eminent English authority, read a paper before the chemical manure manufacturers in London on December 10, 1888, his subject being, Our Supply of Phosphates. Prof. Sibsan, an English chemist, who was present and who commented upon Mr. Voss's paper, spoke as follows:

> With regard to the South Carolina phosphates, I am glad to hear the supply is not likely to diminish, for it is at present the mainstay of the

> phosphate supply, and as a raw phosphate it probably has greater merits, all around, than any other, chiefly because we depend upon the amount of soluble phosphate which can be got from it.

Immediately after this statement was made came the active development of the phosphate deposits of Florida, which had been discovered by Capt. J. Francis Le Baron in 1881, as stated on page 39 of this report. Mr. C. C. Hoyer Miller, an English gentleman connected with some of the largest phosphate enterprises in the United Kingdom, in a pamphlet, published in London in 1891, which he wrote for the information of his friends, entitled The Phosphate Fields of Florida, remarked:

> In conclusion I may add that in the course of the last few years I have closely examined the following phosphate fields; viz., the Somme, Pernes, Breteuil (Oise), and Cambrésis deposits of northern France, the Mons and Liege deposits of Belgium, the Lahn phosphate mines (both coprolite and rock formation) of Germany, the apatite mines of Norway and Canada, and the land and river deposits of South Carolina, and there can be no doubt whatever that there are in Florida the most immense phosphate deposits ever discovered, although these deposits vary in area, in thickness, in quality, and in value to an extent unparalleled elsewhere.

What Prof. Sibsan designated the mainstay of the phosphate supply was strongly reinforced by the discovery of the Florida phosphate deposits, and the already strong position of the South Carolina establishments was augmented, and an impetus was given the industry in this country which has been felt wherever it exists.

The geographical position of the phosphate deposits of South Carolina and Florida is most favorable to their successful development. They are not only accessible to our home markets, but also to those of the great commercial and agricultural nations generally. The Gulf states and the entire Mississippi valley, as well as the South Atlantic, Middle, and Eastern states, and Canada, are all accessible, both by sea and rail, which are facilities of the highest importance in marketing the product of the phosphate mines. The South Atlantic seaboard, the Southwest, West, and Northwest are reached through the great trunk lines which bring these wide areas within commercial proximity to the mines themselves. Thus the markets of a continent are easily reached. A glance at a map shows the directness with which the producers of phosphate in the United States can reach all the great seaboards of other nations. Assured, therefore, of an abundant supply, and aided by a favorable geographical location, the phosphate industry of the United States may now be regarded as occupying an exceedingly strong position. This position is growing stronger year by year, for with the advent of high grade Florida rock and its cheaper production, Canada and Spain, which have produced some phosphate and had a place in the phosphate market, have, owing to their inability to compete with the Southern states, practically dropped out of this market, and notwithstanding a later discovery of phosphate in France, the Phosphate Company of France, composed of large capitalists, and having extensive holdings in the French mines, have within the past year made valuable purchases in Florida, investing probably not less than half a million dollars. These men are well informed, and their action is more significant than any prognostications as to the duration of the profitableness of French phosphate mining as compared with American.

The South Carolina phosphate industry, inaugurated, as stated, in 1867–'68, has become established, its development assured, and its product well known wherever commercial fertilizers are in use. The industry in Florida, however, is not yet established, and a great many contradictory views exist concerning it. There has been and still is much glamour surrounding it. Many estimates are exceedingly optimistic, while some are the reverse of this. Unwise and speculative investments have been made in Florida, disturbing the steady development of the industry; but divested of the exaggerated estimates made by over-sanguine men, and allowance having been made for fluctuations in prices and for the mistakes and omissions necessarily attendant upon the establishment of a new enterprise as great as this, the phosphate mining business, in its latest analysis, as brought out in this report, has shown a remarkable progress. Even among the inexperienced the failures have been few, while those who brought experience and business methods to the development of the industry have had almost phenomenal success.

The data furnished for this report prove it to be a reasonably lucrative business; with experience will come the introduction of a better system and more approved methods. The machinery, most of which was modelled after that used in the earlier days in South Carolina, is being more and more adapted to the mining performed under the altered conditions found in Florida, the laborers employed are becoming better disciplined and more skilful in the performance of their duties, while inventive genius is at work on new appliances whenever the processes admit or require it.

All these facts indicate development and improvement, and must necessarily place the business upon a still safer and more profitable basis. As phosphate is a staple article, like bread and meat or coal and iron, it must find a ready and profitable market. It is one of the chief essentials to all vegetable and animal life, one of the first elements of plant food to become exhausted, and one of the most expensive elements to restore to the soil. No doubt can exist, therefore, that the phosphate industry of the Southern states, with its millions of capital and thousands of skilled and unskilled workmen, is firmly established as one of the leading industries of the United States. (a)

The plan of treatment of this report is to take up the leading features of the industry as it exists in Florida and South Carolina. Many quotations, taken from works which are now rare, will be found, but which are so important that it is deemed wise to reproduce them here. Following the text treatment will be found the statistical results of the investigation ordered by the Senate.

In this investigation the phosphate deposits of Georgia and North Carolina play no particular part. In the former state the only workable deposit that has thus far been developed is to be found in Thomas county, near the Florida line, and this deposit is believed to be an offshoot of the Florida deposits. The location of the deposit in Georgia will be found on the map showing the Florida deposits, and its character and extent are described in connection therewith.

The deposits of North Carolina are found in several counties in the southeastern part of the state. They are generally of a conglomerate character, and, though brought into notice in 1884, they have been developed only to a limited extent. But one company is at present engaged in mining, and that in an experimental way. The results, however, are brought into the general statistics.

In considering the phosphate industry of South Carolina and of Florida, much more has been said concerning the latter than the former state. This is the natural result of several causes: first, the area of the phosphate deposits of Florida is much greater than that of South Carolina; second, the number of mines in operation in Florida is 106, as shown by this report, while in South Carolina but 30 mines are being operated; and third, the conditions surrounding the industry in Florida differ in

---

a Phosphorus is one of the most universally distributed of all the elements. It is found in all animal and vegetable matter, as well as in most eruptive and sedimentary rocks. Phosphoric acid composes over 40 per cent. of the ashes of bones, and in the vegetable kingdom it is especially abundant in the seeds of plants. Thus the ash of wheat contains over 49 per cent. of phosphoric acid.

It has been estimated that for each cow kept on a pasture through the summer there are carried off, in veal, butter, and cheese, not less than 50 pounds of phosphate of lime. Consequently, it will be seen that phosphoric acid is one of the most important elements of plant food, and no soil can be productive which is destitute of it. The necessity of restoring phosphoric acid to an exhausted soil has been acknowledged from very ancient times, though the cause of its stimulating effect was unknown until a comparatively late date. In the days of the Romans the excrements of birds from pigeon houses and bird cages brought a high price; and Edrisi relates that the Arabians, as early as 1154 A. D., used the guano deposits found along their coast for agricultural purposes. Garcilasso de la Vega (Comentarios Reales, lib. V., 1604) says that the Peruvians, in the twelfth century, used the guano beds on their islands as fertilizers. Of such importance did they esteem the material of these beds that the penalty of death was imposed by the early Incas on any one found killing the birds that made these precious deposits. It was not, however, until the early part of this century, when Liebig and others showed the important part played by phosphoric acid in vegetable life, that artificial manures came into use, and it is only in the last 20 years that the mining of natural phosphates, with their conversion into superphosphates, has assumed its present great and steadily increasing importance.—The Nature and Origin of Deposits of Phosphate of Lime by R. A. F. Penrose, jr., Bulletin No. 46, United States Geological Survey, 1888.

many respects from those existing in South Carolina. The development of the industry in Florida is of great interest to those engaged in phosphate mining in South Carolina, as many of the concerns in the latter state are interested in such development. The phosphate industry of South Carolina, too, has probably reached its maximum proportions, and the amount of phosphate in sight is small compared with that in sight in Florida. At the present rate of output, the South Carolina mines will be exhausted in about 28 years from 1891, while in Florida the conditions promise an output for a much greater length of time. The industry in South Carolina has been written up many times, and exhaustively. These reasons make it necessary to treat the industry in Florida more fully than the industry in South Carolina, and to introduce illustrations bearing upon it.

The value of the discovery of phosphate, from an agricultural standpoint, can not be overestimated.

Previous to 1841 the principal commercial fertilizer was bone dust, that being the only form of phosphate of lime then known. About the year 1833 Thomas Graham, a Scotch chemist, had made a careful investigation into the chemical nature of phosphoric acid and phosphatic salts. The result of his investigation was the widespread use of bone dust as a fertilizer. It was found, however, that it was necessary to use as much as 1,000 to 1,200 pounds per acre to secure the best results, owing to the fact that the phosphate of lime in bones is so slightly soluble in water.

In 1841 guano was introduced from the Chincha Islands of Peru. Because of the greater solubility of this fertilizer and the consequent better results obtained from its use the demand for it rapidly increased. At this time Liebig, the German chemist, discovered and formulated the method of making soluble the phosphate of lime contained in bones by treating the bone dust with sulphuric acid. It was found at that time that 1 bushel of the bone dust dissolved in one-third its weight of sulphuric acid was superior to 4 bushels of the bone dust not so treated.

The beginning of the active development of the phosphate industry in South Carolina in 1867 and in Florida in 1888 was most important, owing to the inadequate and rapidly decreasing supply of bone and other manures. The relation of the development of these deposits to agriculture and the effect that may be expected when the deposits have been more fully worked are so intimately connected that the consideration of the one leads naturally to the other. They came at a time when much of the best farming land was beginning to show the wasting effect of years of tilling without any adequate return to the soil of that very important element of plant food, phosphate of lime. Competition for the farmer has been increased by a growing population, and by opening up the rich and virgin lands of the western part of our country. Not only must he meet this in the markets where he sells his product, but also in the hiring of labor. Improved implements have increased the productive capacity of man, and now comes this great store of phosphate to increase the productive capacity of the land. More fortunate still, these deposits are located within easy reach of the oldest agricultural centres, where the strongest evidences of the impoverishment of the soil are discernible. In addition to this, the magnitude of these deposits makes it possible to furnish an abundant supply at a low price. As the fertility of the soil is the essential basis of profitable farming, and as agriculture is one of the most important elements in the wealth and welfare of the nation, it is thought to be within the scope of this report to publish for more general information certain extracts and tables having an important bearing upon the subject.

The following interesting and instructive extracts are from The Phosphates of America, by Francis Wyatt, Ph. D., New York, 1892:

> Sixty years ago the science of agriculture was in its infancy. Our grandfathers could not understand why lands once so fertile and productive should show signs of approaching exhaustion. The light only came to us after we had studied how outdoor plants live, whence they obtain their food, of what elements that food is composed, and how it is conveyed and absorbed into their organisms. In point of fact, we have discovered that the manner of life in plants is very similar to the manner of life in animals and man. They require certain foods in stated proportions which pass through the process of digestion; they must breathe a certain atmosphere; and they are subject to the influences of heat and cold, light and darkness.
>
> The tissues of their bodies, like ours, are composed of carbon, hydrogen, oxygen, nitrogen, and certain mineral acids and bases, such as phosphoric and sulphuric acids, lime, potash, magnesia, and iron. Since, therefore, it is admittedly necessary for man to constantly absorb a sufficiency of these elements in the form of food, it follows that similar food is required by plants for similar purposes. Having determined the elementary composition of plants, investigators directed their attention to the analysis of soils, in order to establish comparisons between virgin or uncultivated lands and old varieties which had long been tributaries to every kind of culture. It was found that in the former there is an abundance of most of the dominating mineral ingredients discovered in plant organisms, whereas in the latter they either exist only in minute proportions or are lacking altogether. This marked a most important stage in our progress. Argument is no longer necessary to prove that if agriculture is to continue to be the basis of national wealth and prosperity, means must be found of restoring to our soils the chief elements yearly taken away from them by the crops. These chief elements have been shown to be nitrogen, phosphoric acid, and potash; and that they play the most important parts in the functions of vegetation, and are the most liable to exhaustion, is proved by the following figures borrowed from an address delivered by Prof. H. W. Wiley at the Buffalo meeting of the American Association for the Advancement of Science.

According to this careful and painstaking chemist, the estimated mean annual values of some of the agricultural products of the United States closely approach the following figures:

MEAN ANNUAL VALUES OF CERTAIN AGRICULTURAL PRODUCTS IN THE UNITED STATES.

Product.	Quantity.	Value.
Wheat	450,000,000 bushels	$440,000,000
Maize	1,900,000,000 bushels	627,000,000
Oats	600,000,000 bushels	168,000,000
Barley	60,000,000 bushels	33,000,000
Rye	25,000,000 bushels	14,000,000
Buckwheat	13,000,000 bushels	7,280,000
Potatoes	200,000,000 bushels	100,000,000
Butter, milk, and cheese		380,000,000
Fruits		100,000,000
Rice	98,000,000 pounds	4,900,000
Vegetables		50,000,000
Tobacco	483,000,000 pounds	42,000,000
Cotton	6,500,000 bales	250,000,000
Wool	300,000,000 pounds	45,000,000
Hay	45,000,000 tons	360,000,000
Miscellaneous, including flax, flaxseed, hemp, grass seed, garden seeds, wines, nursery products, etc.		408,945,000

MEAN PERCENTAGE OF ASH OR MINERAL MATTER CONTAINED IN THE MOST IMPORTANT OF THESE PRODUCTS.

Product.	Per cent. of mineral matter.	Product.	Per cent. of mineral matter.
Wheat	2.06	Hay	7.24
Maize	1.55	Cotton stalks	3.10
Oats	3.18	Straw of wheat	5.37
Barley	2.89	Straw of rye	4.79
Rye	2.09	Straw of barley	4.80
Buckwheat	1.37	Straw of oats	4.70
Rice	.39	Straw of buckwheat	6.15
Potatoes	3.77	Stalks of maize	4.87

APPROXIMATE QUANTITIES OF MINERAL MATTERS TAKEN FROM THE SOIL BY A SINGLE CROP OF THE CEREALS.

Product.	Weight (pounds).	Per cent. of ash.	Weight of ash (pounds).
Wheat (grain)	27,000,000,000	2.06	556,200,000
Maize (grain)	106,400,000,000	1.55	1,649,200,000
Oats (grain)	19,200,000,000	3.18	610,560,000
Barley (grain)	2,880,000,000	2.89	83,232,000
Rye (grain)	1,400,000,000	2.09	29,260,000
Buckwheat (grain)	650,000,000	1.37	8,905,000
Total			2,937,357,000
Wheat (straw)	45,378,000,000	5.37	2,436,798,600
Maize (stalks)	212,800,000,000	4.87	10,363,360,000
Oats (straw)	32,000,000,000	4.70	1,504,000,000
Barley (straw)	4,800,000,000	4.80	230,400,000
Rye (straw)	2,333,000,000	4.79	111,750,700
Buckwheat (straw)	1,083,000,000	6.15	66,604,500
Total			14,712,913,800
Grand total			17,650,270,800

Since it is our intention to limit the scope of this work to phosphates, we may neglect all other constituents of the above amounts of ash, and confine our attention to the quantity of phosphoric acid removed yearly from the soil in the United States.

QUANTITY OF PHOSPHORIC ACID REMOVED YEARLY FROM THE SOIL IN THE UNITED STATES.

Product.	Weight, ash (pounds).	Per cent. of phosphoric acid.	Weight, phosphoric acid (pounds).
Wheat (grain)	556, 200, 000	46. 98	261, 302, 760
Maize (grain)	1, 649, 200, 000	45. 00	742, 140, 000
Oats (grain)	610, 560, 000	23. 02	140, 550, 912
Barley (grain)	83, 232, 000	32. 82	27, 316, 742
Rye (grain)	29, 260, 000	46. 93	13, 731, 718
Buckwheat (grain)	8, 905, 000	48. 67	4, 334, 063
Total			1, 189, 376, 195
Wheat (straw)	2, 436, 798, 600	4. 81	117, 210, 012
Maize (stalks)	10, 363, 360, 000	12. 66	1, 312, 001, 376
Oats (straw)	1, 504, 000, 000	4. 69	70, 537, 600
Barley (straw)	230, 400, 000	4. 48	10, 321, 920
Rye (straw)	111, 750, 700	6. 46	7, 219, 095
Buckwheat (straw)	66, 604, 500	11. 89	7, 919, 275
Total			1, 525, 209, 278
Grand total			2, 714, 585, 473

The acreage under cultivation for the production of the above cereals is estimated officially as follows:

ACREAGE UNDER CULTIVATION.

Product.	Acres.
Wheat	40, 000, 000
Maize	75, 000, 000
Oats	23, 000, 000
Barley	2, 500, 000
Rye	1, 800, 000
Buckwheat	900, 000
Total	143, 200, 000

The quantity of phosphoric acid per acre is, therefore, for the whole cereal crop, 19 pounds.

For the hay crop a similar estimate may be made of the quantities of plant food removed. The mean percentage of ash in the grasses of the United States is 7.97; for timothy it is 5.88; for clover it is 6.83. The mean content of ash may consequently be taken at 6.89 per cent. The total weight of hay produced, multiplied by this number, gives 6,201,000,000 pounds as the total weight of ash in the hay crop of the United States.

For the ash of timothy the percentage of phosphoric acid is 8.42; for red clover, 6.74. The mean percentage of phosphoric acid in the ash of timothy and clover is, therefore, 7.56.

The total weight of phosphoric acid in the hay crop is, therefore, 468,795,600 pounds.

The number of acres harvested in the United States is about 37,500,000, and the quantity of phosphoric acid removed per acre is, consequently, 12½ pounds.

In the springtime phosphates are found in noteworthy quantities in young organs of plants, especially in the leaves, but the quantity gradually diminishes as the plant approaches maturity, until when the blossoms appear the phosphates are found to have entirely quitted the leaves and accumulated in the seeds. This is the cause of that peculiar effect which has long puzzled farmers, that fodder cut and brought in after the period of maturity proves to be much less nourishing to the cattle than that cut before this period has arrived.

* * * * * * *

Mr. Boussingault, writing upon the same subject, says: "We perceive a certain constant relation between the proportions of nitrogen and phosphoric acid contained in foods, those being richest in the latter element which contain most nitrogen. This would appear to indicate that in the vegetable organization phosphates particularly cling to the nitrogenous principles, and that they follow the latter into the organization of animals." The absolute necessity for the presence of phosphoric acid in the soil needs no further discussion. It is admitted on all hands that in its absence, vegetation, even when abundantly supplied with nitrogen and all other necessary elements, must come to a standstill. The form in which it is assimilated is that of phosphate, produced by the combination of the acid with various bases. Enormous deposits of phosphate, chiefly of phosphate of lime, have been and doubtless will continue to be discovered in every quarter of the globe; and as, besides being so essential to plant life, it is the principal constituent of bones, we have here another proof that if by some extraordinary phenomenon its source were suddenly cut off or exhausted, all vegetable and animal life would cease. So far back as the year 1698 a celebrated French engineer (Vauban), writing in the Dime Royal, said: "We have for a long time past been universally complaining of the falling off in the quantity and quality of our crops; our farms are no longer giving us the returns we were accustomed to; yet few persons are taking the pains to examine into the causes of this diminution, which will become more and more formidable unless proper remedies are discovered and applied." This was a warning note, but it was not until after the commencement of the present century that the English farmers began to use crushed bones as a manure, and even then they did so in blind ignorance of the principles to which they owed their virtues, as is clearly shown by an article published by one of the scientific papers of that day (1830), in which the writer says: "We need take into no account the earthy matters or phosphate of lime contained in the bones, because as it is indestructible and insoluble it can not serve as a manure, even though it is placed in a damp soil with a combination of circumstances analytically stronger than any of the processes known to organic chemistry." A subsequent writer upon the same subject declares that "bones, after having undergone a certain process of natural fermentation, contain no more than 2 per cent. of gelatin, and as they derive their fertilizing power from this substance only, they may be considered as having no value as manure." That such opinions as these should have prevailed only 50 years ago seems to us all the more preposterous because of the gigantic strides which we have made since then, and because of the singular fact that even the Chinese were better informed than our grandfathers, inasmuch as they knew that the fertilizer was a mineral principle, and for many centuries have used burnt bones as manures. Despite the unflagging researches of the best men of the time, it was not until the year 1843 that the Duke of Richmond, after an exhaustive series of experiments upon the soil with both fresh and degelatinized bones, came to the conclusion that they owed their value not to gelatin or fatty matters, but to their large percentage of phosphoric acid. The spark thus emitted soon spread into a flame, and conclusive experiments shortly after published by the illustrious Boussingault set all uncertainty at rest forever. Numerous species of vegetables were planted in burnt sand, which was ascertained by analysis to contain no trace of phosphoric acid. It was, however, made rich in every other element of fertility. No development of these plants took place until phosphate of lime had been added to the sand, but after this addition their growth became flourishing. Meanwhile large workable deposits of mineral phosphates were already known to exist, they having been almost simultaneously discovered in their respective countries, by Buckland in England, Berthier in France, and Holmes in America; and in the course of a lecture delivered to the British Association in 1845, Prof. Henslow, describing the Suffolk coprolites, suggested the immense value of their application to agriculture. From this time may be dated the development of phosphate mining as an industry, the pursuit of which has proved so remunerative to capital and labor.

* * * * * * *

Speaking of the advantage to be derived from the application of finely powdered raw phosphates, Dr. Wyatt says:

Nothing of any serious moment has in fact occurred to modify the conclusions formulated in 1857 by the well-known Frenchman, De Molon, who, reporting on a very extensive series of trials of ground raw coprolite in many different departments of France, said that: "1st. It might be used with advantage in clayey, schistous, granitic, and sandy soils rich in organic matter. 2d. If these soils were deficient in organic matter or had long been under cultivation, it might still be used in combination with animal manure. 3d. It may not be used with advantage in chalky or limestone soils."

Here, as it strikes us, is a fairly representative case where an intelligent discrimination is demanded of the farmer, and where he must realize that the term soluble as applied to phosphate fertilizers is an entirely relative one. In one portion of his lands he may use raw phosphates, and they will prove to be soluble and produce excellent results; in another portion, owing to different constitution of the soil, they will remain insoluble and the result will be *nil.*

* * * * * * *

Prof. E. T. Cox, at the Washington meeting of the American Association for the Advancement of Science, August 20, 1891, referring to the use of crude phosphate as a fertilizer, says:

But why convert the pebbles into an acid phosphate? The acid phosphate is reverted into phosphate of iron and alumina after it is applied to the land, by the presence of iron and alumina that are found in all arable soils. It is, in my opinion, far more economical for the farmer to apply to his land the phosphate of lime in the form of a fine powder than to apply the acid phosphate.

In this case, the more phosphate of alumina it contains the better, as it will be more readily assimilated by the plants than reverted phosphoric acid, which results from the application of superphosphates to soils containing iron and alumina.

In connection with the foregoing, Prof. Cox quoted from a letter of Henry Wurtz, Ph. D., to whom he had submitted his paper. Dr. Wurtz writes:

> What you say about a merely mechanical treatment, in the preparation for use of these phosphatic gravels, that is, mainly by fine comminution, meets the approval of my own mind, through my own reading, experience, and investigation in every way. The efficacy of phosphates as fertilizers is rationally explainable by their conversion into polymeric forms, soluble in the liquids which occur in the soil or arise from the natural excretions of the radicles of plants, or from products of plant decay. Such excrements, *suo al.*, convert phosphates into soluble polymeric or other forms.
>
> Mulder claimed that these solvent or transforming agents are the organic acids of decay, such as those called humic, ulmic, crenic, apocrenic, etc. H. von Liebig, some ten years since, claimed that roots secrete or excrete oxalic acid, which alone, or with the ammonia of the soil or of the air or of both, dissolves solid phosphates.
>
> Gladding proved that organic salts of ammonia can completely dissolve or cause to pass into solution, not only lime, but alumina and iron phosphates. Other chemists (as Millot) have shown that ammonia salts even prevent the reversion or precipitation of dissolved phosphates in the soil. It is undeniable that great mechanical comminution has been proved by numerous experiments to be almost if not quite as efficient as chemical solution in the promotion of the absorption of phosphates by plant radicles. If the clayey phosphates (meaning the soft phosphate herein described) you describe should really pan out 50 per cent., or even less, of tricalcium phosphate, with or without iron and aluminum phosphates, its importance appears to me incalculable. The mass of remarkable and significant chemical facts, in the literature of soils and fertilizers, has surprised me; apparently no master mind has yet reduced them to any available system of soil science.

CHAPTER I.

THE PHOSPHATE INDUSTRY OF FLORIDA.

CHAPTER I.

THE PHOSPHATE INDUSTRY OF FLORIDA.

Prof. Sharples, one of the leading New England chemists, says, in the Boston Herald, concerning the Florida phosphates:

> In my opinion it is the greatest industrial discovery that has been made for many years, as well in the matter of its vast extent as in that of its high grade of richness.

The mineral phosphate industry is still in its infancy. Interest in the subject was first excited by the experiments of the Duke of Richmond in 1843. He discovered that bones owed their value as a fertilizer, not to their gelatine or fatty matter, as was popularly believed, but to their large percentage of phosphoric acid.

In the meantime, workable deposits of mineral phosphate of lime were discovered, and the industry may be said to date from 1845, less than half a century ago. The literature on the subject is, therefore, meagre, though so far the importance of the subject has enlisted for it the thoughtful consideration of some of the ablest agricultural and scientific writers of our time.

GEOLOGY OF THE PHOSPHATE FIELDS OF FLORIDA.

In treating this subject, so important from a scientific, commercial, industrial, agricultural, and economic standpoint, it has been customary to give at least a synopsis of the geology of the territory under consideration.

Through the kindness of Dr. N. A. Pratt, of Jacksonville, Florida, we are enabled to use as a part of this report what he has written on the subject.

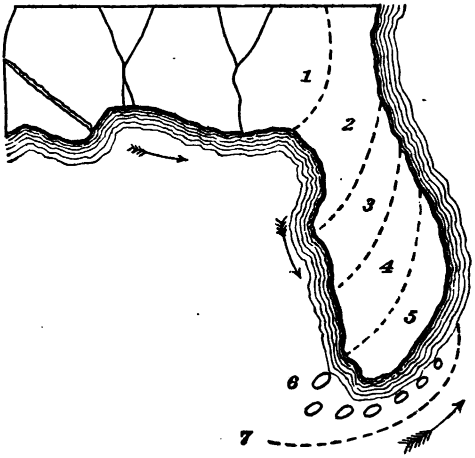
Dr. Pratt was an associate of Prof. Francis S. Holmes of South Carolina, and with him a pioneer in the phosphate industry of the United States, having been constantly engaged as a geologist, mining engineer, and chemist, either directly or indirectly, with the mining or manufacture of phosphate, since he and Prof. Holmes first discovered the commercial value of the South Carolina deposits in 1868.

While studying the geological formations of South Carolina, with reference to her phosphate deposits, he was led to pursue the subject still further, and took up those of Florida, having the same purpose in view.

The result of his studies and conclusions was embodied in a pamphlet entitled, The History of the Discovery of South Carolina Phosphates, 1868. In this pamphlet he refers to the geological history of the formation of the peninsula of Florida as follows:

> There was a time, very recent in geological ages, when the peninsula of Florida had no existence, but the Gulf Stream, after circling the western and northern shores of what is now the Gulf of Mexico, swept its silent and majestic course by a shorter and more direct route to the shores of the Carolinas. At that time its warm current and the shelving beach of adjacent shores afforded peculiar facilities for the growth of this coral animal, which in its thousand forms flourished in its genial waters. Unable to live at a greater depth than 40 to 60 feet, its branching forms rapidly spread out seaward, until at 60 feet depth no foothold could be obtained. Its outward progress was limited by deep water and it could only grow upward toward the surface of the water, attaining which, the outer branches farthest from the shore, luxuriant in the clear, uncontaminated ocean water which laved their gorgeous sea front, flourished and rose in walls of living reefs to the very surface of the sea, inclosing in their rear a shoal or partial lagoon or salt-water inland river. In this swarmed thousands of species of marine life—fish, shell, and coral, vertebrates, molluscans, crustaceans, and radiates. All found in it a general habitat, the weaker and more defenceless varieties attracted by the security which the living walls of coral afforded, the more voracious and stronger by the easy prey thus penned up and confined, apparently for their own benefit, while thousands of sea fowl frequented its lonely shores. Meanwhile, the storms and waves dashing against the exposed wall of living coral cast up huge monsters of the deep and impaled or entangled them there, and breaking down the long, branching coral trees, ground down to powder the broken fragments of coral shell and bore and buried all in a common grave, or, dashing them over the outer reefs, deposited the larger fragments above the water level or forced the finer portions into the quiet lagoon within, where, settling in the bottom, in a short time was formed a soft, calcareous paste, the original of our marl beds. Gradually a sparse soil forms on these reefs, scanty vegetation takes root, soil accumulates, and the reefs become a series of keys or coral islands, separated by narrow and shallow channels or inlets connecting the open sea with the shoal or quiet lagoon within. While this is going on another reef is forming in front, and the larger rivers of the main bring down their burdens of light mud and sand and deposit them also in the open lagoon, simultaneously with the pure calcareous mud. Thus the lagoon gradually fills up with calcareous mud and sand, and ultimately the range of keys or islands is connected with the main by a low, swampy everglade, buried in the mass of which are the bones, carcasses, and excrementitious deposits of the thousands of living forms that frequented the lagoon. These ultimately became coprolites or guano-like deposits of birds, reptiles, and fish. These deposits, leached by rain and other waters, losing all the soluble ingredients, the residue consists essentially of the insoluble phosphates of lime, derived originally from the bones and tissues of the animals devoured by the millions of birds and predaceous animals that frequent these shores.
>
> By such means as these, beyond a doubt, a prominent headland, or low, projecting savannah, was originally formed along the coast, from which now projects the peninsula of Florida. By successive growths

of coral reefs, changes of these into keys, and of keys into mainland, accompanied by a gradual and slow elevation, the peninsula was elongated and will continue to elongate until adverse circumstances restrict and limit its extension. The accompanying map makes this plain.



No. 1 shows the original headland formed by coralline agency.

Nos. 2 to 5 show the lines of old reefs and coral islands or keys, which have become successively annexed to the main through the agency of the sediment brought down by the great rivers, Mississippi, Apalachicola, Alabama, and others, which, taken up by the current of the Gulf Stream, has been conveyed and deposited in the quiet waters of the circumscribed lagoon within.

No. 6 shows the line of existing islands or keys now being slowly annexed to the main.

No. 7 shows the outer line of reefs now being changed into keys.

Thus it happens that the whole peninsula is underlaid by widely concentric lines of coral reefs and keys, and by nearly horizontal layers of rotten limestone (coralline marl), sand, and soil, and the transition can be readily traced from the outer reefs, No. 7, to the range of keys, No. 6 (which extend westward to the Dry Tortugas), and from these to the low, swampy everglades, thence to the high fertile hammocks and savannahs and the sandy pine lands of the main.

In 1890, twenty-two years after the publication of the foregoing, Dr. Pratt was employed to examine and report upon a large phosphate property of about 8,000 acres, scattered along the valley of the Withlacoochee river and lying within the counties of Marion, Citrus, and Hernando, of the hard rock belt. As an interesting sequel to his Geology of Florida, the following extract from his official report is published by his permission. Speaking of the Withlacoochee basin, as he terms it, where he made a critical examination, he says:

Several opinions and theories as to the origin of the formation have been expressed and published:

First. That of a pure bird deposit, in localities favorable to the roosting of water fowl, more nearly covers the conditions of the problem as presented in all localities than any other so far advanced, but the evidences are all opposed to this theory in the case of the Withlacoochee river deposits and can not be entertained here, for certainly this form of phosphate of lime has never existed as vertebral bone, the basis of bird deposit.

Second. That the underlying lime rock contains a certain percentage of lime phosphate as an integral part of its composition, say 5 per cent., and that the lime carbonate being dissolved by carbonated soil waters acting on a large surface, there was left the 5 per cent. of insoluble lime phosphate; that is to say, every 100 feet or inches of the lime rock dissolved would leave 5 feet or inches of phosphate of lime in pure state. This is plausible, but its importance is overestimated.

Third. Directly opposed to this, it is held by some that the top surface of lime rock, constantly bathed with phosphates in solution, has changed its carbonic for phosphoric acid, and thus metamorphosed its carbonate into phosphate of lime, just as shells or coral rock are silicified, which is a common occurrence. This theory is more untenable than any advanced; the evidence of the material disproves it, for in every case in which shell impressions occur, a cavity appears indicating the space formerly occupied by the calcareous shell, which has disappeared entirely, leaving only its impression and cast in the phosphate material. In no case have I ever seen a true calcareous shell transformed into a phosphatic shell. My own impression, based on evidence collected here, is that the whole deposit, in all its types and varied forms, had its immediate origin in animal life and agency, and that the phosphate boulder is a true fossil or fragment thereof, the animal extracting lime phosphate either directly from the mineral world (viz., the waters of the sea) as vegetation does, or, more likely, by feeding on lower vegetable organisms that abound therein, and secreting the same phosphate of lime or its own solid skeleton, thus maintaining the accepted law of nature, that no mineral matter can be assimilated and raised to the higher plane of animal life and structure without having previously passed through the lower plane of vegetable life and structure. In this case, however, the animal, if such, was of the lowest type and so closely allied to the lowest type of plant growth that naturalists have scarcely yet agreed as to their affinities.

In this connection it is immaterial how their food was obtained, as the result is the same. Some kinds of sponges, infusoria, and animals of lowest type assimilate directly from the water, or from their food, and secrete silica (fluid); some, carbonate of lime; and some, a horny substance, as their supporting skeleton; and this secretion and growth continue until the environments change—the animals are exterminated and a massive nodule of flint, a cliff of chalk, a coral reef, or a heavy stratum of infusorial casts (silica) or tripoli remains as the result of their life work. Is it improbable that other species may have secreted a skeleton of lime phosphate? Most shells, either fossil or recent, consist mainly of lime carbonate secreted by the animal; some, however, are known to secrete and live in a shell of lime phosphate. The shell of Lingula, of oldest Silurian age, is phosphate of lime, and today a Lingula with phosphate shell lives and flourishes on the North Carolina coast, a fact discovered only a few years ago when attempting to trace and discover the origin of the phosphate material of South Carolina.

If the lynx-eyed miner, manufacturer, or merchant fails to recognize at sight a valuable commercial article, can the naturalist, who seldom is a chemist, be blamed for calling a phosphatic skeleton, a calcareous one?

It is no stretch of the imagination to assume that some of the lowest types of animals, such as zoöphytes, sponges, infusoria, foraminifera, etc., had the power and exercised it in building up skeletons of bone phosphate of lime for the support of their turgid and gelatinous bodies. I have before me many samples of phosphatic boulders, from the size of a match box to 5 and 8 feet in diameter, the most perfect showing a complete spiral or circles of phosphatic material around a central stalk or axis, as symmetrical in the arrangement of its loosely separated concentric laminations, as the encircling leaves of a head of lettuce, which it closely resembles in size and appearance, except the laminations are continuous in concentric if not spiral bands. I am satisfied that the phosphatic boulder of Florida is the fossil remains of a gigantic foraminifer having in every part of its skeleton a composition identical with true bone deprived of its organic matter, but not of its structure. I am constrained to believe that such a structure can only be attributed to life agency, and under no stretch of chemical or physical law can such be called a concretion, nor be formed and shaped by any other power than that of organized growth. I am led to this lengthy explanation in order to say that the evidences lead me to believe that all of the boulders in the ledges or surface exposures, that are classed by me as laminated or conchoidal types, grew as zoöphytes or rhizopods, possibly sponges, but more probably gigantic foraminifera in the spots in which they are now found, just as sponges now grow in favorable localities, and as oysters of gigantic size found in the early Tertiary age grew and flourished in banks under favorable conditions and left their shells, even 16 to 26 inches long, still attached to the bank on which they had thrived so well. I will not attempt to reason out the origin of each of the other types of Florida phosphates, classified and described below, further than to say that types of wedgwood and oriole soft phosphates show to the unassisted eye no indication of organic or organized structure. The microscope may detect it. It is certain, however, that they have a close relation to the boulders above described, since the material is in, around, and under the boulders and is generally embedded in the sand or clay. Accepting as true that I am dealing with gigantic foraminifera, it is not unreasonable to suggest that this white material may be made up of the remains of the germ spores (spawn) or bud of these prolific animals, or is the comminuted débris of the animals themselves, just as soft calcareous marl is the débris of coral reefs that grow and accumulate in practically the same manner. It is probable that the delicate, gelatinous flesh (sarcode) of these lowest types of animals provided abundant food for higher types, in which case the excrement of these marine animals (but not of birds) would consist largely of comminuted débris of the phosphatic skeletons of the food taken. A remarkable fact adds evidence to the strength of my theory as to the organic origin of the material. It is well known that most rock formations, clays, and sands are colored more or less reddish with ferric oxide and that whenever these are brought into intimate contact with organic matter (such as the flesh sarcode of these gelatinous animals must afford) undergoing decomposition, the red ferric oxide is reduced to a soluble form and is readily leached out of the clays and sands, leaving the same pure white and free from every tinge of color. No doubt the same action has bleached the phosphate beds and the associated sands and clays to the almost dazzling whiteness so often seen—in strong contrast to the dirty reddish color of the overlying sands. Finally, the geological age of this deposit is no doubt the middle Eocene Tertiary. The underlying lime rock is true nummulitic lime, named from a peculiar fossil that constitues its chief bulk. It is well known in many parts of the world, is many thousand feet thick in Europe, and was used largely in building the pyramids of Egypt.

I obtained during this investigation, in the lime rock underlying the sand rock in Hernando county, a nummulite 1 inch in diameter, the handsomest one I have ever seen. I have been in doubt, until recently, whether or not the phosphate deposits were of the same age as the lime rock and sandstone or of more modern formation. Of this I am now assured, having found identical fossils in both the sand rock and phosphate rock, and believe the phosphate is of the middle Eocene epoch, Tertiary period. It is my impression that the sand rock, generally a gray and porous mass at the surface, but flinty at the centre and evidently the product of sponge growth, is older than the phosphate growth and underlies it; possibly they grew and flourished simultaneously, each in the locality and environment that best suited it. In any case, the latter outlived the former, perhaps overpowered and exterminated it; hence it follows that the phosphate may be reasonably looked for alongside the flinty type of sand rock, but will not be found among the underlying lime rocks except where it has subsided into a lime sink or like depression. I am of the opinion, also, that the whole nummulite bed, with its flinty sand rock and phosphate banks, is a deep water formation; of this, however, I am not assured.

I find that the many hundred forms and varieties that strike the casual observer as different, both in quality and composition, can be classified and arranged in groups of a few typical forms of such striking general character that they may be easily recognized and their chemical composition be predicated, approximately, in the type.

First. The laminated type. Hard boulders or fragments thereof more or less distinctly compacted in layers, sometimes with interstices between the laminæ filled with sand or clay or else empty, sometimes compact and solid, but in all cases the laminæ can be distinctly traced in the fractured edges and are curved concentrically or spirally around a central point like the leaves of a head of lettuce, except that the laminæ are continuous. In a small boulder the curvature is distinctly traced in the fractured edges; on a larger one the curvature may scarcely be detected, and the laminæ appear as plates or slabs. The color is brown, amber, gray, or white, but generally of one color from the same locality; they all have a coarse, harsh, hackly fracture. I have seen the laminæ from one-sixteenth of an inch to 1 inch thick.

The average composition of this type, whatever the color or whereever found, is practically the same. An average of 18 analyses of this type yields, excluding sand—

Constituents.	Average sample.	Purest sample.
	Per cent.	*Per cent.*
Lime carbonate	7.53	7.46
Combined water and organic matter	3.23	2.50
Aluminated oxide of iron	3.21	.60
Lime phosphate	80.88	84.95
Sand, insoluble	....	.10

Organic matter is uniformly present and in connection with its peculiar structure indicates organic origin and structure.

Second. The conchoidal type. Hard boulder, generally smooth, sometimes polished exterior, solid and massive within. The fracture is smooth and conchoidal like the interior of a conch shell; color, cream, white, or light gray, sometimes intricately banded with irregular or broken streaks of darker color. This type is of common occurrence, but if exposed at the surface to forest fires may become very hard, rough to the touch, and discolored by iron oxide or partly lose the smooth fracture so common in the underground boulder. It is uniformly nearly free from sand and insoluble matter and contains organic matter and carbonate of lime, indicating organic origin. Its average composition, computed from 16 analyses, freed from sand, is—

Constituents.	Average sample.	Purest sample.
	Per cent.	*Per cent.*
Lime carbonate	6.25	5.75
Combined water and organic matter	4.10	4.10
Aluminated oxide of iron	2.15	1.28
Silicic acid combined	1.00	1.75
Phosphate of lime	83.53	86.32

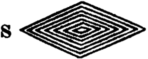
Third. The wedgwood type is boulder-like, has semi-conchoidal fracture that looks like wedgwood or semi-porcelain ware, is dry and rough to the touch, brittle, and rings under the hammer; breaks in all directions with equal facility, is generally white and cream color, though sometimes stained and spotted. It is found in banks, is prominent in the Withlacoochee basin, and is a valuable rock. The tough, white, rain-pitted rock may be included with this. Its average composition, computed from 20 analyses, freed from sand, is—

Constituents.	Average sample.	Purest sample.
	Per cent.	*Per cent.*
Lime carbonate	6.43	....
Combined water and organic matter	3.85	3.85
Aluminated oxide of iron	2.25	3.44
Lime phosphate	83.71	86.44
Silicic acid	....	2.10

Fourth. The oriole type. This is a soft mass occurring in layers, irregular strata, or masses sometimes of several feet thickness and considerable area. It is perhaps the most widely disseminated and most abundant of all the types. Pure, it is chalk-white in color, soft and satin-like in feeling. It is porous and light when dry, and smooth and fine as pearl powder. When mixed or wetted it holds from 30 to 40 per cent. of water, works under the fingers to a pasty mass, is easily shaped and moulded, and dries into a hard cake, friable, but of considerable tenacity. When subjected to heat in other than its natural or moulded state it becomes tough, resists abrasion, and loses more or less of its smooth feeling, does not shrink in bulk nor crack, nor is it restored to its former condition by soaking in water. It is almost free from sand and grit, but contains alumina. It invariably occurs under and around the boulders and extends laterally beyond them and underlies tracts of land where no boulders are found. Sometimes it is harder and heavier than described, but having similar composition, both kinds are classed together. In its pure state it is, unfortunately, closely associated with intervening beds or layers or pockets of pure white sand or clay, or both, which is difficult to separate, and the grade is reduced thereby.

Constituents.	Average sample.	Purest sample.
	Per cent.	*Per cent.*
Combined water and organic matter	2.01	5.60
Lime carbonate	4.55	2.68
Aluminated oxide of iron	12.60	2.30
Lime phosphate	78.10	87.64
Soluble silica combined	2.75	.75

Fifth. Another type is as white as oriole, but in ledges or boulders, though sometimes soft and smooth to the touch. It is compact and heavy. On exposed surfaces it appears deeply pitted, as if by raindrops, but this is probably due to the growth of a species of lichen. Along with it occurs rock of the wedgwood type, and as their compositions are so nearly the same, I think it best to class it under that head or type and call it wedgwood, too, for the present at least.

Sixth. The fossil type, so called from the fossil impressions contained; viz., cavities like this  from one-eighth to sixth-eighths inch. This fossil, called orbitoides, accompanies the nummulite in all nummulitic limestone and in this state is a characteristic fossil of a sand rock that overlies the prevailing lime rock, and which is not a sponge flint rock. I have not learned where the sample came from, but know it can only be found close in the lime rock below. It is of good quality, hard boulder, brown in color, breaks in all directions easily, exposing the cavities shown above. The fractured parts are very harsh and sandy in one piece, more smooth in another; in any case the cavities will identify the type. It resembles sand rock so closely that it might be rejected in mining. Analysis of the roughest and most unpromising piece yields—

Constituents.	Average sample.	Purest sample.
	Per cent.	*Per cent.*
Sand and insoluble	2.95	
Alumina and ferric oxide	3.65	
Lime carbonate	4.40	
Phosphoric acid		36.32
Bone phosphate of lime	79.43	
Lime		48.72

Seventh. The river rock type consists of either or all the above types, except the oriole, all darkened even to blackness by the staining action of the water and mud and exclusion of air. It is sometimes blue, sometimes pink, and even green at the surface. They seem more massive and heavy than any of the other types. A sample from Blue Spring in the Withlacoochee river basin run above 82 per cent. phosphate of lime. All these forms or types run more or less into each other, yielding mixtures of more or less uniformity, dependent also on the quantity of clay and sand that may adhere to them.

From the study of these typical forms it may be observed—

First. That their close approximate composition indicates a common origin, the lime phosphate averaging 78 to 88 per cent., apparently depending on the varying amounts of water, lime carbonate, alumina, and iron oxide, Second. That the iron oxide is seldom as much as 1 per cent. and sometimes entirely absent. The alumina varies from a trace only to as much as 12 per cent., and this from one of the finest oriole samples. The average of all the analyses is between 3 and 4 per cent. When more than this is found it is due to the solvent action of strong acids in the clay element, and I notice that the clays in this country are more soluble than other clays or kaolinites.

Third. The lime carbonate runs from 3 to 7 per cent., except when found near the lime rock below, where it reaches 8 to 10 per cent., but this is rare.

Fourth. Calcium fluoride in the harder varieties, in no case have I found more than one-fourth per cent. to 1 per cent. This is evidence that the material is not derived from the bones of vertebrate animals, which uniformly contain more.

Fifth. Organic matter exists to a limited extent in both the laminated and conchoidal types.

Sixth. Combined water is always present in excess of what the silicate of alumina would indicate, in what combination I have not had time to investigate.

Seventh. The absence of magnesia and sulphuric acid is conspicuous. Chlorides are present. In general the specific gravity of all the types is described to be 2.25 to 3.25.

GEOGRAPHICAL POSITION OF THE FLORIDA PHOSPHATE BELT.

The phosphate belt of Florida, as applied to the workable deposits having an economic and commercial value, commences at the head of the Wacissa river, in Jefferson county, about 4 miles south and 18 miles east of Tallahassee; thence it extends southeast to the Aucilla river, near a point where the three counties of Jefferson, Madison, and Taylor join, where deposits of considerable extent and of fine quality are found; thence through Taylor county, with a trace or straggling deposit here and there, by a southeast course to the Steinhatchee river in Lafayette county, where large and valuable deposits have been located. Directly north of the Steinhatchee phosphate region, and chiefly on the east bank of the Suwannee river, and around the little village of Luraville, large bodies of high grade composite phosphate have been located. Thence the belt extends southeast again for a distance of about 25 miles, with very little evidence of phosphate on the way, and Ichetucknee springs, in Columbia county, is reached, around which are some rich deposits. Leaving the springs and travelling south, indications are seen here and there. Passing near the town of Fort White and the rich deposits in its immediate vicinity, crossing the Santa Fe river, and traversing this hard rock territory for a distance of 24 miles, High Springs in Alachua county is reached; thence due south, are deposits scattered all about for 24 miles to the Albion region of Levy county, to the westward of the tracts just described. Straggling along a distance of about 20 miles, in the western part of Alachua and Levy counties, from north to south, is the Trenton region, where fine composite phosphate lands, rich and easily worked, have been located.

Returning to Albion and travelling south and east through Levy county, 15 miles to Stafford's Pond, thence on through Marion county, taking in on the way a number of rich mines in the Early Bird region, we reach the Dunnellon mines, where the discovery of hard rock phosphate was originally made, where the first mine was opened, and where is now the largest hard rock company in the state. Crossing the Withlacoochee river, the belt extends a little east of south through the rich and favored mineral counties of Citrus and Hernando, broadening out and reaching so far to the east as to take in the western border of Sumter county, again veering to the west, thence on to a point 4 miles south of Dade City in Pasco county, where the southern limit of the hard rock belt is reached. Its total length from Ichetucknee springs to the point named is about 160 miles, through a broken but continuous chain of phosphate deposits, its general trend being north-northwest to south-southeast with an average width of 12 to 15 miles, in several places widening out so as to embrace, in a fragmentary way, as much as 20 miles. To the east, and parallel with the hard rock belt, and lying almost wholly within Marion county, is what is known as the plate rock region, of which Anthony, Welshton, Belleview, and Summerfield are the present active centres. The plate rock belt extends from Orange Lake on the north to the southwest corner of Lake Weir on the south, a distance of 30 miles or more, with an average width of 2 to 3 miles. The thriving city of Ocala falls between the hard rock and plate rock belts, making it the phosphate centre for a large extent of country. The territory from Ichetucknee springs to Dade City is described as the phosphate belt proper, because it is more compact and better defined, but including the Luraville, Steinhatchee, Aucilla, and Wacissa rivers and deposits adjacent thereto, hard rock may be found for a distance of more than 200 miles, in its course traversing the counties of Jefferson, Madison, Taylor, Lafayette, Suwannee, Columbia, Alachua, Levy, Marion, Citrus, Hernando, Sumter, and Pasco. In a general way it conforms to the configuration of the Gulf coast, but touches it nowhere, and only in one place approaches as near as 8 miles. The territory described is known as the hard rock belt, because the phosphate is hard, as its name implies, and is generally high grade, and though subject to several subdivisions, is believed to be of a common origin.

The subdivisions are: 1st, hard rock; 2d, plate rock; 3d, composite, a mixture of hard rock and fragmentary stuff, to which may be added the gravel screenings and soft phosphate which generally constitute a considerable part of the matrix of the hard rock boulders. Sometimes the gravel is found as drift, and the soft phosphate frequently isolated and detached from other forms. Again, moving southward, the abruptness of the change is broken by a considerable deposit of soft phosphate near Richland, 4 miles south of the southern extremity of the hard rock belt, and thence for more than 20 miles a strip of flatwoods country, entirely destitute of any indications of phosphate, is crossed. South of the high ridge upon which Lakeland is situated, the land pebble region spreads out for 30 miles east and west, at right angles with the general trend of the deposit already described, covering a large territory, and distributing itself along the water courses that permeate this section of Polk and Hillsborough counties and finally make their way into the Alafia river, which has its outlet in Tampa bay.

The force of the drift having been broken by the escape of the overflow into the basin of the Alafia and its tributaries, again gathers itself together at Lake Hancock, where it becomes more contracted, and resumes its southern course, following the Peace river valley to the Gulf at Charlotte harbor, on its way sweeping through the counties of Polk and De Soto. The waters in their passage continually drop the pebble, which becomes incorporated with the land adjacent to the river and in places for some distance beyond, filling all lakes, creeks, ponds, prairies, and depressions, and covering the beds of the river with a stratum of from a few inches to many feet. Each annual flood and every freshet scouring out the headwaters and tributary streams, and washing away the yielding banks, sets free an additional supply of the phosphate pebble. In places the volume of the drift overleaped the barriers of these small streams and found its way into Manatee county and the river of that name, and also the Miakka river, where the land and river pebble proper loses some of its identity by becoming more or less mixed with animal fossil phosphate, which contains a considerable percentage of silica and quartz. Further south, in Lee county, the Caloosahatchee river opens up another field, but disconnected from that described and of a different origin. Of the land pebble belt the Peace river may be said to be the eastern boundary, for though it crosses the river in places, nowhere as yet has it been found far beyond. Going back again to the hard rock belt, and starting from a point near Ichetucknee springs, a drift of pebble phosphate seems to have passed over the sandy plain directly east along and across the headwaters of the Santa Fe and New rivers, leaving a considerable trace in Bradford county, thence through Clay county to Black river, where it found an outlet, but as it swept along it parted with much of the pebble with which it was loaded, which found a resting place in the valley and bed of Black river. This Black river phosphate seems to be identical with that of the Peace or Alafia rivers, except that it carries quite a percentage of silica, but being a non-absorbent this has not been found objectionable.

In Wakulla county, on the Sopchoppy river, is found another considerable deposit, but entirely different in character and in origin from the hard rock or land pebble belt. It is very much the same as that of

Charleston, there being present large quantities of fossil bones of both land and marine animals, and the soft porous limestone, in which much of it is embedded, being saturated with the phosphoric acid, has become transformed into a lower grade of phosphate. This deposit was discovered several years before the hard rock, and at that time attracted much attention from scientists and others, but its limited area and its remoteness from transportation prevented its development. In the meantime the discovery of the enormous high grade hard rock deposits diverted attention to the new and more attractive field. Traces of phosphate, as stated, have been found in Bradford county, also Hamilton county, the eastern part of Madison county, and farther west in Leon, Gadsden, and Washington counties. But none has yet been developed, and therefore it is impossible to determine the value or extent of the deposits. About 30 miles directly north of the deposit first described at the head of the Wacissa and Aucilla rivers, over the state line in Thomas county, Georgia, is a fugitive or outlying deposit of a number of small pockets of hard rock, covering something like 1,000 acres. This will be found noted on the map near the little town of Boston. This deposit, which is believed to have some connection with the Florida deposits, is the only one thus far discovered north of the Florida line of sufficient value to warrant working. Including both the hard rock and land pebble fields of Florida, the distance from the northern extremity to the southern limit is about 240 miles, the distance from the eastern to the western extremities being about 125 miles. Following the two belts in their meanderings from Charlotte harbor to the head of the Wacissa river, the distance is about 325 miles, but the deposits are broken and detached like the reefs and oyster bars on the seacoast, which, no doubt, at one time they much resembled in appearance, for there is ample evidence of their having been laved at one time by the tides of the ocean. This description, with the aid of the map which accompanies this report, will give a very correct idea of the geographical location of the Florida phosphate deposits.

TOPOGRAPHY OF THE FLORIDA PHOSPHATE BELT.

In the first year of the discovery of phosphate many theories were entertained concerning its relation to the physical features of the country, but in the light of experience and a fuller development of the several phosphate fields, these views are no longer entertained, and it is now pretty generally acknowledged that there is no relation whatever between the two, save that of accident. It was once believed that the belt followed the rivers, but the map will show that it follows its own course without reference to the directions the rivers take. Some held that phosphate could not be found on the hills, others that it could not be found in the swamps, others thought they could tell it by the timber, and said that the scrub palmetto would not grow on phosphate land, and

RRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

still others said that there was some incompatibility between hammock (hard wood land) and phosphate; but all of these theories have been refuted, for it has since been found under each of the conditions named.

The phosphate belt commences in the foothills of the rolling country of middle Florida, makes its way over the flatwoods and pine forests of Taylor and Lafayette counties, thence into the higher level of Suwannee county, and continues to High Springs in Alachua county. There it reaches the backbone of that country, with an elevation of probably 100 feet or more, over which it extends for 40 or 50 miles. It passes through all manner of forest growth and every character of land from rich hammock to the poorest sand hills, through flatwoods, swamps, and rolling land, with the greatest diversity of soil and timber. Turn either to the east or the west and one or two hours' travel discloses with what regularity the phosphate belt kept on its course, crossing rivers or paralleling them, but when the separation came, it was the river that changed its course, not the general trend of the phosphate belt. This, of course, applies to the hard rock belt proper, which is recognized by some of the ablest scientists as being in place. The plate rock, land pebble, etc., are drift or, as some describe them, alluvial deposit, and naturally take to the water courses, where accessible, as in Polk, Hillsborough, De Soto, and Manatee counties. In its course the hard rock belt embraces elevations of from 15 to 120 feet, and in several places reaches a higher altitude; indeed, if the belt has shown any preference, it is for the high ridge or backbone, with its undulating surface, which it accompanies for so much of the distance. The absence of water on the greater part of this ridge is another feature, mines having been sunk 60 feet without encountering it. In many cases—indeed, where the mine takes the water-shed—the water that flows into it sinks and disappears. In Taylor and Lafayette counties the lands are generally flat and low, and in mining, pumps or drainage will have to be resorted to, and in some of the clay lands water has given trouble; but as a rule, from the Suwannee river to Pasco county, water gives little or no trouble, and the topography of the country is rather favorable to economical mining.

The map shows the intimate relation the phosphate belts, hard rock and land and river pebble, bear to river and railroad transportation to the seaboard. Though active prospecting has been carried on by land owners and others since the discovery of phosphate in Florida, the past year has added very few new deposits to those already located, and these have been almost wholly within the well defined limits of the belt. The map is brought down to January 1, 1893, which enhances its value as reliable reference.

DISCOVERY OF PHOSPHATE IN FLORIDA.

The eccentricity of phosphate deposits will, in a great measure, account for the long delay of their discovery, after the occupation and settlement of the country.

In the ruins of the old clay chimneys, which were in the winter quarters of Gen. Andrew Jackson, the fragmentary phosphate contained in the clay can still be seen scattered about.

Boulders as large as flour barrels were frequently used as underpinning for houses. Smaller boulders were used in the construction of chimneys and sugar furnaces, and in Fort Meade it was used as a desirable paving material for the sandy sidewalks. Yet phosphate is marked by many singularities which distinguish it from other formations; indeed, now that it has been discovered, all are surprised that the material, which was so common to those sections of the state now embraced in the phosphate belts, had not been recognized. While neither the state nor the United States government had attempted a geological survey, several scientists of reputation had made a preliminary examination. The animal fossil deposits on the Sopchoppy river, in Wakulla county and elsewhere, had been brought to their attention, but the largest deposits of the hard rock and land pebble phosphates, though traversed by them time and again, failed to attract the skilled eye, even of these experts. Their failure may be attributed partly to the fact that all were looking for deposits similar in character to those found in South Carolina. Probably the best explanation of the almost purely accidental discovery of these rich and wonderful deposits may be found in Prof. N. S. Shaler's introductory remarks to Dr. Penrose's Nature and Origin of Deposits of Phosphate of Lime, Bulletin No. 46, United States Geological Survey, 1888. Prof. Shaler says:

> It will be evident to the reader of Dr. Penrose's report that the workable deposits of phosphates are found in a greater variety of circumstances than those which contain most mineral substances that have an economic value. * * * Although local concentrations of phosphatic nodules, other than those now known, may well be sought for in the Southern states, I do not think that the precise conditions or character of the deposits as found at Charleston should be expected to repeat themselves elsewhere. It is characteristic of the process of concentration of phosphatic, as well as of other matter into nodules that the material takes on a great variety of aspects, each proper to a particular site, and this although the surrounding circumstances of the several localities may apparently be identical. * * * Unfortunately, the unfamiliar aspect of the various forms of phosphatic deposits will make this task under any circumstances difficult. There is no substance of equally wide diffusion among those of considerable commercial importance which, in the present state of popular knowledge, so readily escapes detection as lime phosphate.

From the time of the discovery of the South Carolina phosphates, many persons in Florida had taken much interest in the subject, and in some way connected those wonderful deposits with the seacoast and tide water, many believing that deposits of equal value might be found somewhere in the broad expanse of the ocean bound peninsula of Florida. This interest took shape and crystallized so far as to repeatedly urge upon the legislature of the state the advisability of a geological survey, with the purpose of ascertaining definitely what lay beneath the surface. The legislature never responded, and the discovery of the rich deposits in Florida, the largest in the world, was left to chance.

As early as 1879 traces were found and reported from Hawthorne in Alachua county, a sort of sporadic deposit hanging upon the fringe of the now well defined belt. Analysis was made and showed 45.72 per cent. phosphate of lime. Some attempt in 1884 was made to work it, but only in a small way. Other discoveries were made in the same region, but none of them are now considered of much value. In 1887 the Sopchoppy or Wakulla county deposits were discovered, but their remoteness from transportation was an insuperable obstacle to their development. In the winter of 1888–'89 Mr. Adam Eichelberger, of Marion county, discovered upon his orange grove on the Withlacoochee river a strange looking substance, which excited his curiosity, and which he believed to be gypsum. A little later, about May 1, 1889, Mr. Albertus Vogt, while having a well bored on his place, near the now famous Dunnellon mines, had his auger fouled, which, in his efforts to clear it, became disjointed. In digging down to clear the auger he came upon a bed of considerable thickness of what is now known as soft phosphate, which opened the way to the hard rock. Samples were carried to Ocala and placed in the hands of Dr. R. R. Snowden for analysis. The result was as much a surprise to Dr. Snowden as to any one else. He reported that the analysis proved the substance to be phosphate of lime of high grade, being over 76 per cent., and told the parties, some of whom were ignorant of the value of phosphate, that if the deposit was abundant it was better than a gold mine. The 10 acres of poor land upon which the well was located, within a few weeks sold for $10,000, and within a few months Mr. Vogt realized $60,000 as the fruits of his discovery. Mr. Eichelberger, who had stimulated the excitement by his search after gypsum, was also rewarded, for he not only discovered gypsum of a good quality, but in close proximity, on the same tract of land, rich beds of phosphate. The business men who had been taken into the secret by Mr. Vogt cautioned secrecy, and immediately sent samples to chemical laboratories in New York, Philadelphia, and Chicago, the analysis from each being confirmatory of Dr. Snowden's report.

Within a few weeks thousands of acres of land lying along the Withlacoochee river were secured, under a small option, at a nominal price. Capitalists were then taken in, and what is now known as the Dunnellon Phosphate Company was organized. The mysterious but active manner in which so many men were moving about in a sparsely settled and hitherto quiet section of the country, could not escape the observation of the curious for a great while. Gradually the facts became known, the contagion began to spread, the whole country was aroused, and men, women, and even the children became prospectors for the coveted phosphate which was to bring riches to the fortunate finder.

The extent of the deposits was a mere matter of individual surmise and opinion, and buyers were apprehensive that the Dunnellon company had already secured the greater part of the deposits, and that unless they bought early they would lose entirely the great profits that all agreed would accrue from so rich a discovery. This was not the idle talk of inexperienced men, but the conclusion of steady going business men from nearly all the great cities, and of eminent geologists and chemists. Men would rush into print and prove by figures that an acre of phosphate was worth millions. The most prominent newspapers of the state published estimates made in all seriousness, of 2,000,000 tons to a single acre. In order to show the highly excited condition of the public, the following clipping is given:

To the Editor of the ———:

If you own 40 acres in phosphates, only 1 foot thick over the entire 40 acres, it will produce 160,000 tons; if 5 feet thick, 800,000 tons; if 15 feet thick, 2,400,000 tons.

If an average of 80 per cent. phosphate of lime and less than 2½ per cent. of iron and aluminum, you can get $24.45 per ton, delivered in London, England. It will cost you to mine, roast, and load on cars at the mines, $3 per ton; freight, insurance, etc., to London, say, $7 per ton; total expenses per ton, say, $10. This will leave a net result of products of $14.45 per ton delivered in London. If above figures are correct, 40 acres of solid rock phosphate, 80 per cent. phosphate of lime and free from impurities, would bring the neat sum of about $33,000,000. Good enough. It takes time and money to bring out above results, but they will come.

In the light of several years' experience in practical mining, and the sober, solid, and indubitable facts recorded, such statements as those given are almost incomprehensible, but at the time these wildly exaggerated statements were given there was at least some foundation for the estimates made. Men had actually dug test pits through 35 feet of comparatively solid phosphate, and the weight of a cubic yard was ascertained to be something like a long ton, or 2,240 pounds. In those days people had not troubled themselves about establishing the outlines of a deposit, which would give the superficial area, but took it for granted that there were acres upon acres of it. At that time for some reason there was doubt about the supply of phosphate, and high grades especially increased in price, being worth as much as 30 cents per unit, making 80 per cent. phosphate worth about $24 per ton. It is recorded of the earlier cargoes of high grade Florida phosphate, that some of them actually netted the shippers over and above expenses, mining included, $10.80 per ton. Under these circumstances, active and industrious prospecting soon extended to almost every county in the state, and to this general interest we are indebted for the early location of the workable deposits, and the defining of the boundaries of the several fields.

The discovery of the Peace river and land pebble phosphates was made prior to that of the hard rock, but excited little more than local interest, many looking upon the operations and investments of the few engaged in it as more of an experiment than an assured fact, but the "hard rock boom," which had been heralded abroad and excited so much interest, gave emphasis, significance, and greater prominence to the river and land pebble belt. Soon prospectors and capitalists, by their locations and purchases, showed their appreciation of their value and importance. The following from Hidden Treasures, by Dr. Jay Shrader of Bartow, Florida, 1891, gives what is generally received as the true story of the discovery of the Peace river and land pebble phosphates:

> In the winter of 1881, the chief engineer of a detachment of the engineer corps, United States army, was engaged with his party in making surveys for a canal from the headwaters of the St. Johns river to Charlotte harbor; and it was while thus engaged, and when surveying Peace river, that he made the discovery of Florida's hidden treasures. The civil engineer was Capt. J. Francis Le Baron, then on the staff of Maj. Gen. Q. A. Gillmore, United States army, under whose orders he was acting. Capt. Le Baron, fully appreciating the scientific as well as commercial importance of his discovery, sent 9 barrels and boxes of fossils to Prof. Baird of the Smithsonian Institute. Prof. Baird was greatly interested in the discovery, and requested Capt. Le Baron to make a complete geological survey of the Peace river valley, in conjunction with certain paleontologists whom he (Baird) would send down from Washington, but the matter being referred to the commanding officer, Gen. Gillmore, he replied that he could not spare Capt. Le Baron for that purpose. Some months later Capt. Le Baron was transferred to Fernandina, where, as chief engineer, he had charge of the improvements of the harbor and of the mouth of the St. Johns river; and, engaged in various duties of the government service, he was unable to visit Peace river again until 1886. At that time he reëxamined the deposits and dug a number of test pits. He also sent off a lot of samples and had them analyzed to convince certain Jacksonville and Philadelphia capitalists of the immense value of the pebble deposits; he urged them to buy or bond the entire Peace river valley, * * * but they could not see it. In vain Capt. Le Baron addressed moneyed men in New York, in Boston—everywhere; all alike were skeptical and would not invest a dollar, though one of the men appealed to (whom the writer happens to know) could then have got control of the whole river for but little more money than he has since invested in one mine. About this time (1886–'87) Capt. Le Baron was offered a lucrative position—that of chief of an engineering expedition to Central America to lay out the Nicaragua canal—and despairing of ever being able to interest capital in his discovery he accepted it and sailed for that country, from which he did not return until a year ago. Put it into all the school histories of Florida (they will probably outlive this pamphlet) that Capt. J. Francis Le Baron discovered Florida phosphate, A. D. 1881.

COMPARATIVE MERITS OF THE HARD ROCK AND PEBBLE BELTS.

The hard rock miner is content with the advantages he claims, and not many would consider a proposition looking to an exchange, while the pebble men express great surprise that the superiority which they claim is so poorly appreciated by the hard rock men. Hard rock comes in great boulders like kegs and barrels, runs high in phosphate of lime, and brings a much higher price, though the cost of mining can as a rule be safely placed at twice that of land pebble, and three times that of river pebble. The pebble, both river and land, comes slowly but surely and with great regularity, and a week's work counts up amazingly, but it carries much less phosphate of lime and brings a lower price. Experience, good management, and economy enter so largely into the business that it is difficult to decide which is the more remunerative grade. Then, too, phosphate mining of any kind is a most fascinating and alluring occupation, warping insensibly the judgment of those engaged in it, and inclining them to that kind with which they have had most to do. Conservative and clear-headed business men, who have visited both sections with a view to investing, have found it most perplexing after weighing all the pros and cons.

ESTIMATED PHOSPHATE IN SIGHT IN FLORIDA.

The acreage of the several kinds of phosphate is given with due allowance for new discoveries and undeveloped and unknown lands; with the percentage of true phosphate land to area; with the average yield per acre, in tons of 2,240 pounds; and with the aggregates of the same. These estimates are based upon many months' close study of the several fields, the measurement of lands already mined, the product of which has been ascertained, and a comparison of notes and observations, with those of the best informed experts, phosphate prospectors, mining engineers, and intelligent miners actively engaged in the business. By way of further explanation, hard rock yields from 100 or more tons per acre to as much as 25,000 tons of boulder rock for a bonanza mine, to which we may safely add 50 per cent. for the gravel or fragmentary stuff found in the matrix and in the form of drift immediately around the mine, thus giving a possible maximum of 37,500 tons. Our estimate is based upon 25 per cent. of this, or 9,375 tons, as an average yield per acre, and we estimate the true hard rock area as 1¾ per cent. of the total area of the belt. Soft phosphate, constituting as it does a considerable part of the hard rock belt, we estimate as ¾ per cent. of the total area of the belt; the soft phosphate found in pockets and in the matrix of the hard rock mines is included, and an average yield of 5,000 tons per acre allowed. For the composite, consisting of pockets of hard rock and drift of fragmentary phosphate, with the acreage not extensive, and the prospecting having been done with more than usual care, 10 per cent. of the area is allowed and a yield of 3,000 tons per acre given. Plate rock is more circumscribed than the other deposits, is more accessible, and has been more thoroughly exploited, and purchases have been made in smaller tracts and more carefully considered. For these reasons 15 per cent. is allowed for the area, and the yield, which has been pretty well established, is given at 2,500 tons per acre. Much of the land pebble belt was located without regard to the deposit, but for the purpose of controlling the river beds through the riparian rights thus obtained. Consequently 1 per cent. is deducted for this and 9 per cent. instead of 10 allowed for area, with an average yield of 2,250 tons per acre. These estimates cover all workable phosphate deposits, both good and bad, and embrace both the lands carefully selected and those located by entire sections for speculative purposes upon imperfect exploitation. The estimate given for river pebble is in gross, and includes the Peace, Miakka, Caloosahatchee, Manatee, Alafia, Withlacoochee, and Black rivers and their tributaries, and is based upon the best information that could be obtained from a number of parties engaged in river mining. The soft phosphate of the land pebble belt, being more or less combined with land pebble, is classified with land pebble.

ESTIMATE OF PHOSPHATE IN SIGHT IN FLORIDA.

Kind of phosphate.	Acreage by land numbers.	Add 10 per cent. for unknown, etc.	Total acreage.	Percentage of phosphate area to total acreage.	Phosphate area in acres.	Average yield per acre (tons of 2,240 pounds).	Total estimated yield (tons of 2,240 pounds).
Hard rock	316, 558	31, 656	348, 214	1¾	6, 093. 75	9, 375	57, 128, 906
Soft phosphate				¾	2, 611. 60	5, 000	13, 058, 000
Composite	56, 589	5, 659	62, 248	10	6, 224. 80	3, 000	18, 674, 400
Plate rock	15, 330	1, 533	16, 863	15	2, 529. 45	2, 500	6, 323, 625
Land pebble	158, 795	15, 879	174, 674	9	15, 720. 66	2, 250	35, 371, 485
Total	547, 272	54, 727	601, 999		33, 180. 26		130, 556, 416
River pebble							2, 500, 000
Grand total							133, 056, 416

A diagram showing the ratio of estimated actual deposits to the total area held as phosphate land is given below:

RATIO OF ACTUAL DEPOSITS TO TOTAL AREA HELD AS PHOSPHATE LAND.

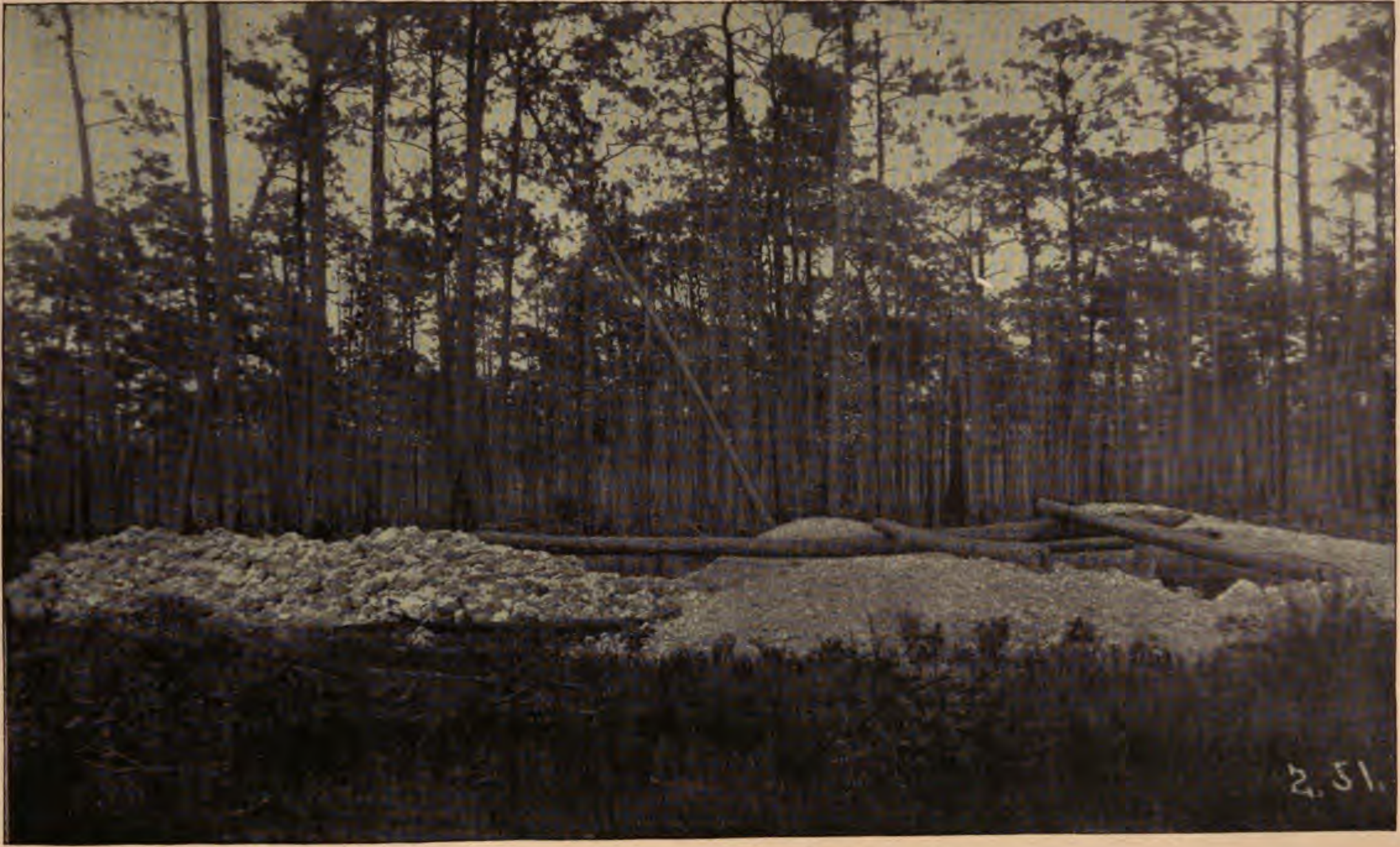
The total area held as phosphate land is represented by the space contained within the rectangular figures—*a* representing the plate rock, *b* the composite, *c* the land pebble, and *d* the hard rock belt. The black portions represent the estimated actual deposits of phosphate in each belt.

KINDS OF PHOSPHATE, MACHINERY USED, ETC.

Hard rock.—The hard rock belt, which covers so large a part of the phosphate field, naturally takes its name from the hard rock phosphate which there predominates, and which may be said to be the basis of at least three other kinds; viz., the gravel screenings, the plate rock, and the composite, with an intimate connection with still another kind, the soft phosphate, one theory of which, that of Prof. Lawrence C. Johnson of the United States geological survey, describes the soft as being formerly hard, but now in process of decay and decomposition, while Dr. Pratt advances a theory directly the opposite, believing the soft to have been the producing cause of all the rest, the spawn or spore from which it originated. The subdivisions into which the hard rock belt and its several products have been divided will be described in their order.

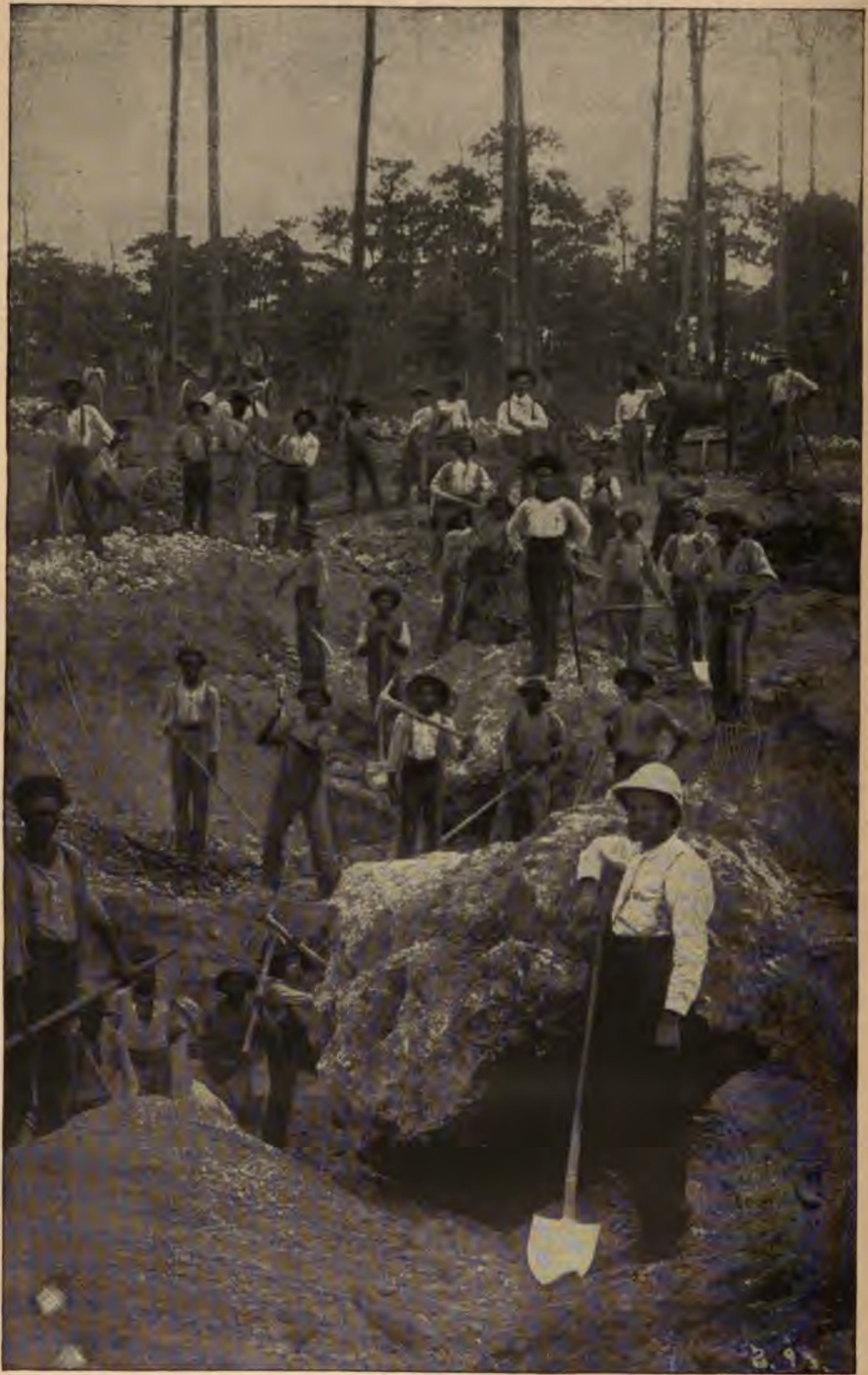
Hard rock is found in boulders of irregular shape and size, and in every possible position. The boulders vary in size from that of an orange to a mass of immense proportions, and in weight from several pounds up to a ton or more—they probably average between 250 and 1,000 pounds. In exceptional cases boulders or great masses of conglomerate phosphate have run together, as it were, forming a compact body of more than 50 tons. In one case, at Oriole in Hernando county, a boulder measured 8 feet by 12 feet by 15 feet, and, being perfectly free from voids and adulteration, must have weighed at least 60 tons. These boulders are usually found in nests of two or more. Sometimes they are found in layers to a considerable depth; indeed, hard rock mines usually run deep, some having been carried as far as 50 and 60 feet below the surface. The greatest peculiarity of hard rock boulders is their irregularity. The rock is surprisingly heavy, compact, and hard, and when broken it makes a clean, smooth fracture. A perfect piece when struck will ring like metal. After scraping off the sediment and mould which forms a crust on the outside, the rock will be found as smooth and fine to the touch as velvet. In its composition all sand and foreign matter appear to have been rejected, leaving the grain fine and delicate.

There are many variations of the several types of hard rock phosphate. One of the most highly prized by the miner is the laminated. As its name signifies, the formation is in scales or layers, one upon another like the scales of a fish, or like so many plates one upon another; these laminæ vary from the thickness of card paper to that of 1 inch or more, generally averaging about one-fourth of an inch. In many specimens you can detect the laminæ only by the lines with which



FLORIDA HARD ROCK PHOSPHATE MINING.

A test pit.



FLORIDA HARD ROCK PHOSPHATE MINING.

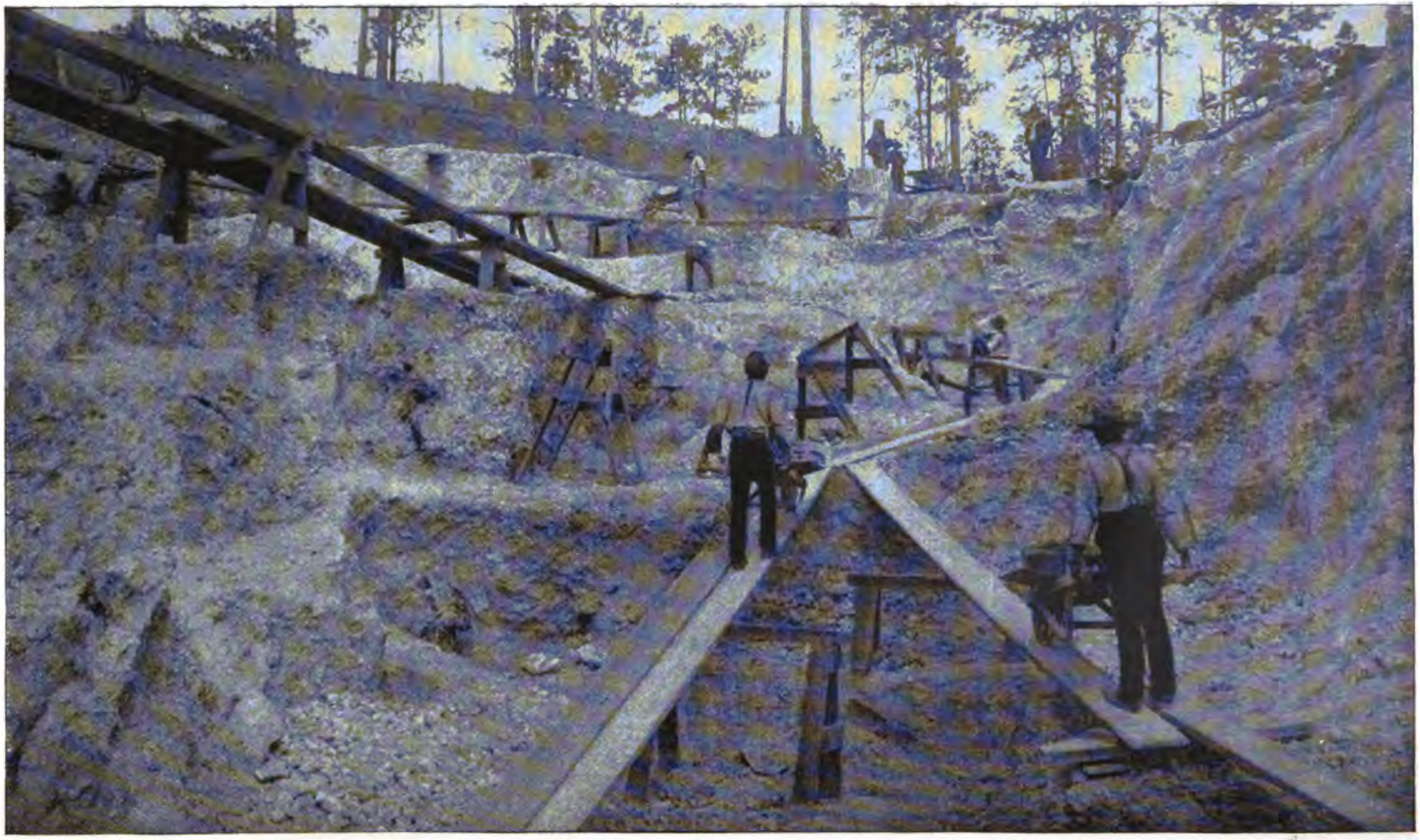
Two large phosphate boulders exposed to view, the overburden having been removed.

they are marked, but usually there is a well defined space between the them. Often there are gaps between the laminæ, the interstices being filled with an adulterant composed of sand, iron, alumina, and other foreign matter, from which the rock must be freed as much as practicable in order to preserve the high grade of the phosphate. Owing to their large dimensions, nearly all the boulders require to be reduced to convenient size for handling by the use of a sledge hammer and steel punch, or in case of larger boulders with dynamite. This hammering, blasting, and breaking process relieves the phosphate of much of the foreign matter, after which it is heaped up on a crib work of cord wood, under sheds to protect it against rain, each shed having a capacity of about 200 tons, where it is allowed to stand until a week or ten days before shipping, when it is fired. This calcining process, with the subsequent handlings, brings it up to a good average condition, and at the same time expels the moisture, which is necessary both to save freight and meet the requirements of the buyer.

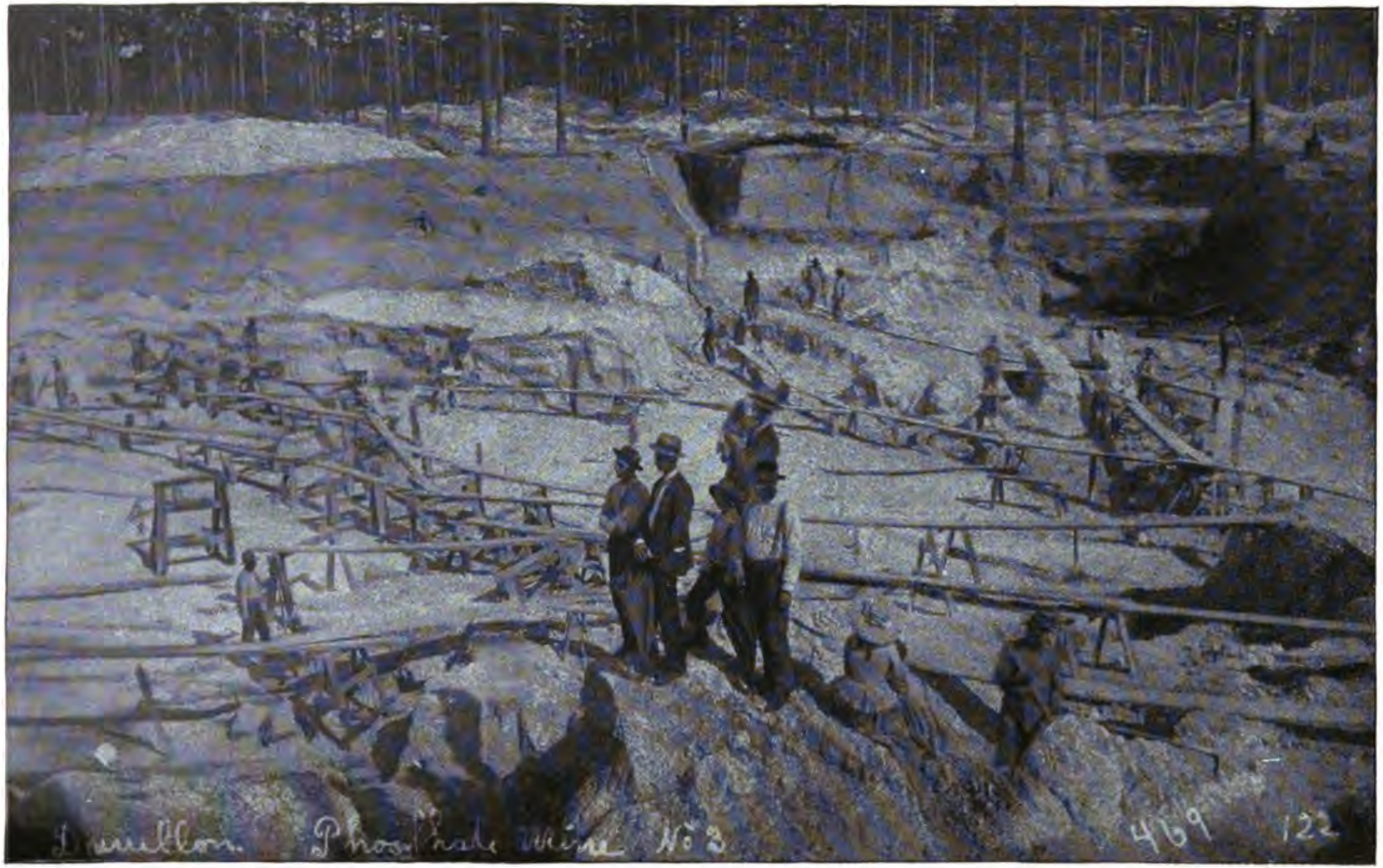
Besides the laminated there are several other forms of hard rock phosphate; some smooth and close knit and without the lines, and some with a rough and wrinkled front, but a smooth interior; other forms look like Tennessee marble in the rough; another form resembles lime rock, and boulders have been found so closely united with flint rock that the line of junction could hardly be detected, and a fracture of one would run into the other. Then there is another form, white and of a large grainy formation; this form is almost as hard as the others, though it does not appear so. Other formations resemble slate rock, and so on in an endless variety. In color the phosphate varies almost as much as in other particulars, taking on white and all shades of brown, gray, yellow, and cream, and sometimes is quite dark and even black. All these colors, save the white, appear to come from a stain of some sort, probably from the soil in which the phosphate is found, or the trees and vegetation that grow upon it, and not unlikely a combination of all. As a general rule, where the soil is moist, the phosphate has a creamy cast, and where there is much clay it shows brown or yellow. Iron, which often exists in the soil, gives it an iron rust color. Light sandy land generally insures a bright, clean white, but whatever the color before taking it out of the ground, a few days' exposure to the sun bleaches it more or less. These many variations in form and color often mislead the miner, but in whatever manner the eye may be deceived there is generally something in the touch and weight by which the skilled miner knows that it is phosphate. Though it may differ in other respects it is nearly all hard and heavy, and when broken, generally smooth to the touch. The analyses of cargoes of thousands of tons show its high character and purity, possessing, as it does, the chief requisites of a high grade phosphate.

The hard rock deposits, like the boulders in the mines, are commonly found in groups, in area from a few square yards to 1, 2, and 3 acres, and in exceptional cases may be as much as 4 or 5 acres, but these are rare. As a rule they run from one-fourth to three-fourths of an acre. Even a full acre in area is uncommon, though there may be, and frequently are in the aggregate, several acres of phosphate on a small tract of land.

In yield phosphate, like other minerals, is irregular, owing to the depth of the deposit. It may be all on the surface, and give only 100 tons to the acre, or it may prove a bonanza mine, and give, including the gravel, 37,500 tons per acre. Often a small superficial area runs the deepest and yields the most. Taking the hard rock belt of workable land, 25 per cent. of the maximum, or 9,375 tons of 2,240 pounds, as an average, is not an unreasonable expectation. Many will easily double it, and the Dunnellon company has a mine of something like three-quarters of an acre, which has already produced 18,000 tons, not including the gravel. However, it should be borne in mind that, as a rule, the best mines are the first opened. The hard rock frequently crops out, showing large boulders on the surface, and covering one-eighth to one-fourth of an acre or more; then it will dip, inclining downward like the shell of a turtle, assuming in outline the most erratic figures. Thus a mine may be opened showing no overburden, but gradually the dip, as it widens, leads the deposit down until many feet of earth will have to be removed to uncover it. The lead is followed as long as the overburden is not too expensive to remove, being frequently followed 20 to 25 feet. Occasionally a mine will run perpendicularly to a depth of 30 feet or more, and then lead off underneath one of the walls of the mine. It may be ever so rich, but it can be reached only by removing that 30 feet or more of overburden, for level or tunnel mining is considered impracticable here, having failed wherever tried. Each mine is an original proposition in which the topography, the overburden, and the deposit itself must be considered. As the work advances new conditions constantly arise requiring judgment and promptness in their decision, for the operations may be at a standstill until a conclusion is reached. Again, in the handling of such bulky materials, great foresight must be exercised in order to conserve the economies in the matter of labor, which is an important item. The superintendent of a mine should be a man of good common sense, practical ideas, quick in reaching conclusions, and in a measure should have the natural talent of an engineer, without the impediments of his instruments and figures. The scientific engineering in surveying the land, locating the deposits, outlining, planning, etc., must be done in advance, for after the mine is once opened there is no time for delay. Hard rock mining possesses advantages over drift mining in this, that it can be done without machinery, and may be carried on by a small or a large force, or may, with great advantage, be supplemented by horse power, even in a small way. In larger



FLORIDA HARD ROCK PHOSPHATE MINING.
A deep cut. Mining by hand.



FLORIDA HARD ROCK PHOSPHATE MINING.

Mining by hand.

HARD ROCK
PHOSPHATE DEPOSIT,
CITRUS COUNTY, FLA.

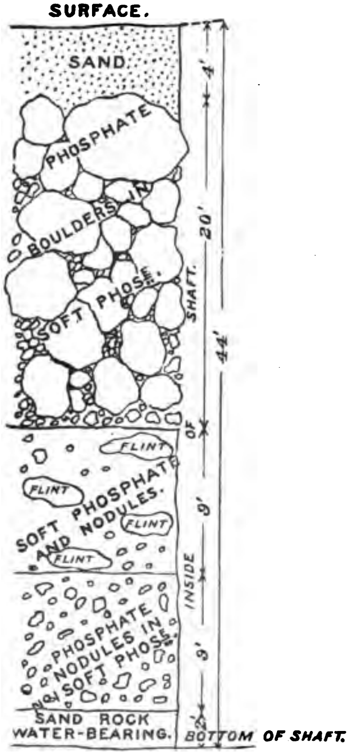
REFERENCES.

S.—*Sand.*
P. R.—*Phosphate Rock.*
C.—*Clay.*
H. S.—*Hard Sand.*
Q. S.—*Quick Sand.*
S. P.—*Soft Phosphate.*
S. P. R.—*Soft Phosphate Rock.*

OVERBURDEN.

Sounding made with a 20-foot rod.
Depths given are to Phosphate Rock, etc.
Other depths show what was found at the depth given.

Developed by D. D. ROGERS,
Civil and Mining Engineer,
Ocala, Fla.


SURFACE.
SAND.
4'
PHOSPHATE BOULDERS IN SOFT PHOSE.
20'
44'
INSIDE OF SHAFT.
FLINT
SOFT PHOSPHATE AND NODULES.
9'
PHOSPHATE NODULES IN SOFT PHOSE.
3'
SAND ROCK WATER-BEARING.
BOTTOM OF SHAFT.

SECTION OF SHAFT.

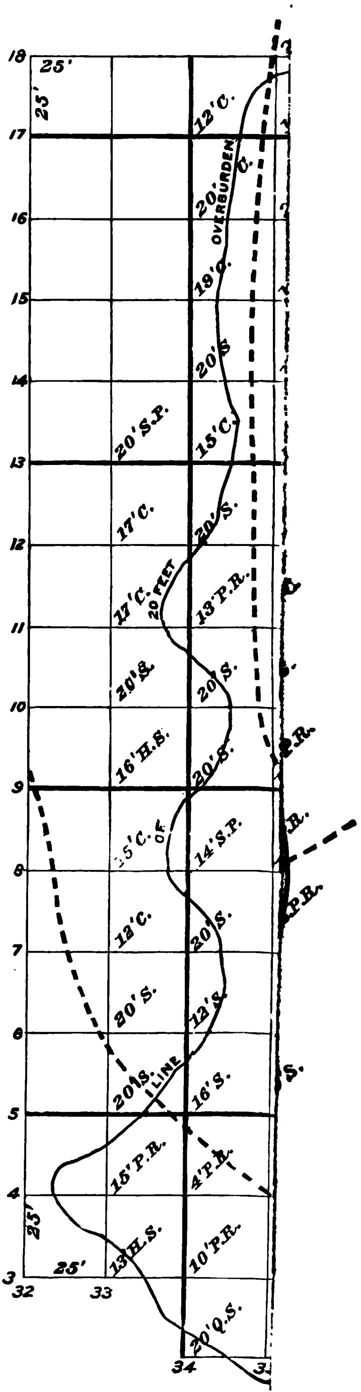


DIAGRAM ACCOMPANYI

operations steam gives increased capacity with a corresponding reduction in the cost of mining.

The cost of hard rock mining is greater than that of drift or river mining, for the boulders must be blasted, broken up, and taken out by hand. At this point the steam hoist may take them, and the shattered fragments of the boulders may be crushed, washed, screened, and dried by mechanical devices, where such process is approved or is necessary to raise the percentage of phosphate or reduce that of the iron and alumina. In most hard rock mines only the simplest of machinery is in use. A steam engine and a cable hoist and trolley may be used, or simpler and probably better, an inclined tramway running down into the mine, using dump cars as vehicles. Hard rock mines run very irregularly, scarcely any two being alike. Everything may be promising at the opening, and then, when least expected, difficulties obstruct the advance. At times great columns of lime rock or sandstone, 20 to 30 feet high, and weighing one or two hundred tons, are found in the centre of good mines. These have to be worked around or blasted and carried out by piecemeal. Again, the hard rock boulders may alternate with large pockets of sand or clay, reducing the percentage of output. The miner delights in a good outcropping to start with, not so much that it gives him any particular assurance of a rich mine, but because he can get to work at once, and instead of spending days and weeks carting off overburden, he at once begins to pile up salable phosphate.

The Istachatta mine in Hernando county, recently opened, has proved a bonanza of this sort. With the first day's work they began to take out the phosphate, which was of high grade, about 80 per cent., and ran very regularly with but little waste. After getting out 2,000 tons one could hardly realize that so much could come from so small a space, so compact had it been in the mine.

In hard rock mining, and this applies to all kinds of land mining, the first thing to do, and one of the most important, is to have the land to be mined thoroughly prospected and staked off, by means of which the outlines of the deposit are traced and the overburden measured or marked upon the stakes, which serve as a guide in the work to follow. In this work two steel sounding rods 12 to 18 feet long are used, and a sectional auger of 20 or 24 feet.

An extract from a report on a hard rock phosphate property, in Citrus county, Florida, reads as follows:

Description.—The general character of the land is high pine land, undulating, well timbered with pine. The soil is of a light sandy nature, changing into a loam a few feet below the surface and in some instances to clay; a water bearing stratum is usually found at a depth of 40 to 60 feet.

Deposits.—On the 360 acres I have found 10 deposits, ranging in area from one-eighth of an acre to 1⅝ acres, having a total area of 5.64 acres, the total overburden ranging from an outcropping to 20 feet in depth. A shaft having been sunk in the largest deposit 42 feet, 32 feet of this being through a stratum of fine grade boulder and gravel phosphate rock, the matrix in several instances was found to be No. 1 (the best grade of soft phosphate) with about 90 per cent. of gravel. Shafts were put down in several other deposits, all of which passed through 20 feet or more of phosphate deposit. The amount of rock practically in sight on the 360 acres is 45,000 or more cubic yards; allowing 24 cubic feet to the ton will give some over 50,000 tons of merchantable high grade phosphate rock, having an overburden (including the necessary slopes) of 10,000 cubic yards.

The deposits are usually situated on a hillside, and in some instances 15 feet above the level of a valley 200 feet distant, giving a decided advantage in removing the overburden and the rock over removing it from a deposit located in a valley.

D. D. ROGERS.

Immediately following are given various tables of analyses, account sales, etc., of Florida hard rock phosphate:

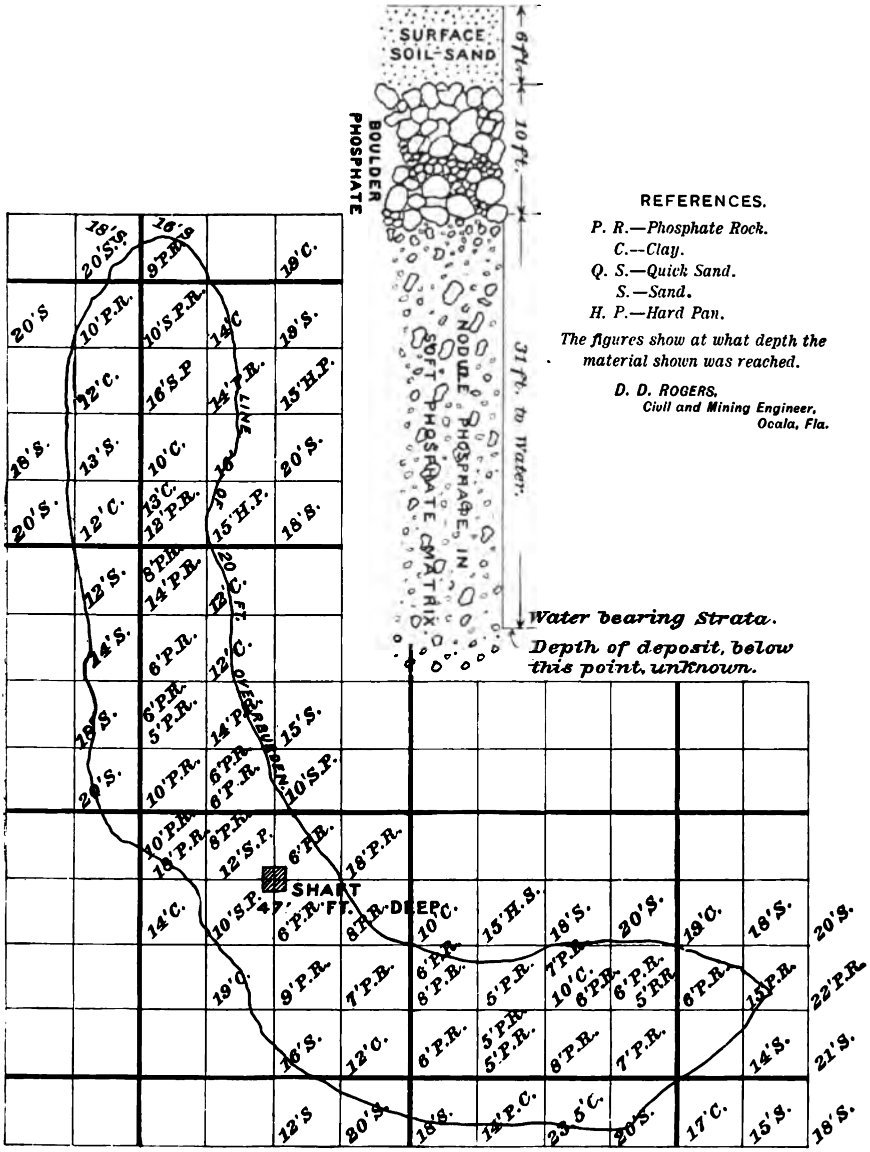
ANALYSES OF A NUMBER OF SAMPLES OF FLORIDA HARD ROCK PHOSPHATE.

Constituents.	Shepard's laboratory, 1,200 samples.	English analyses, 4 cargoes.	O. Grothe, Ph. D., 8 cargoes.	Serge Malyran samples.	B. F. Gibbens' laboratory, 1 cargo.	Average.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Phosphoric acid	37.36					
Phosphate of lime	82.16	78.75	79.80	81.05	78.37	80.02
Carbonate of lime	4.27					
Oxide of iron and alumina	2.38	2.81	2.35	3.23	2.46	2.64
Carbonic acid	1.88					
Moisture	1.70		.58			
Undetermined						

ANALYSES OF SAMPLES FROM A CARGO OF HARD ROCK PHOSPHATE FROM HERNANDO COUNTY.

Constituents.	Augustus Voelcker & Sons.			Bernard Dyer.	
	Per cent.	*Per cent.*	*Per cent*	*Per cent.*	*Per cent.*
Moisture in fine sample dried at 212° F					
Organic matter and water of combination	1.39	.90	.90	1.36	.98
Phosphoric acid	35.11	35.39	35.40	35.57	35.79
Lime	47.07	47.54	47.27	47.09	47.46
Oxide of iron	.65	.75	.75	.81	7.33
Alumina	1.49	1.29	1.71	1.97	
Magnesia	.26	5.36	5.65	3.57	
Carbonic acid, etc	5.54			1.48	
Insoluble silicious matter	8.49	8.77	8.32	8.15	8.44
	100.00	100.00	100.00	100.00	100.00
Equivalent to tribasic phosphate of lime	76.65	77.26	77.28	77.65	78.13
The rough sample contained moisture	2.04	1.51	1.50	2.66	1.45
And accordingly tribasic phosphate of lime	75.09	76.09	76.12	75.58	77.00
Equivalent to carbonate of lime				3.36	

SECTIONAL VIEW
№2. SHAFT.



REFERENCES.

P. R.—Phosphate Rock.
C.—Clay.
Q. S.—Quick Sand.
S.—Sand.
H. P.—Hard Pan.

The figures show at what depth the material shown was reached.

D. D. ROGERS,
Civil and Mining Engineer,
Ocala, Fla.

DIAGRAM ILLUSTRATING THE OFFICIAL REPORT OF ANOTHER FLORIDA HARD ROCK PHOSPHATE MINE.

NALYSES OF SAMPLES FROM A CARGO OF HARD ROCK PHOSPHATE FROM THE DUNNELLON DISTRICT.

Constituents.	A. Sibson.	Aug. Voelcker & Sons.	B. Dyer.
	Per cent.	*Per cent.*	*Per cent.*
hosphoric acid	36.80	36.63	36.73
ime	51.20	49.08	50.06
xide of iron	.52	.74	.70
lumina	1.73	1.60	1.63
nsoluble	3.90	3.39	3.10
ndetermined	5.85	7.93	6.46
rganic matter and water of combination		.63	1.32
	100.00	100.00	100.00
quivalent to tribasic phosphate of lime	80.33	79.97	80.18

SALE OF A CARGO OF BURNT FLORIDA HARD ROCK PHOSPHATE.

Copy of account rendered a Florida mining company by their selling agents in London, with values reduced to American money.]

Tons.	Cwt.	Qrs.	Lbs.					
				LONDON.				
100	8	2	24	analysis B. P., 79.93 per cent				
1	9	3	20	deduct moisture, 1.49 per cent				
98	18	3	4	at $0.2636 per unit per ton			$2,084.62	
113	4	1	21	analysis 77.50 per cent				
2	7	3	3	moisture 2.11 per cent				
110	16	2	18	at $0.2534 per unit per ton			2,177.13	
373	10	0	0	analysis 77.97 per cent				
8	9	2	8	moisture 2.27 per cent				
365	0	1	20	at $0.2433 per unit per ton			6,925.19	
				STOCKHOLM.				
1120	12	1	16	analysis 77.05 per cent				
15	18	1	0	moisture 1.42 per cent				
1104	14	0	16	at $0.2534 per unit per ton			21,574.23	
								$32,761.17
				Less 2½ per cent. on gross sales				819.03
				CHARGES.				31,942.14
				Tons. Cwt. Qrs. Lbs.				
				Freight on 1707 15 2 5 at $4.6384 per ton		$7,895.33		
				Less 2½ per cent. address commission		197.40		
							7,697.93	
				Insurance and stamps	$337.88			
				Less 10 per cent. on 65£ 2s. 6d	31.69			
						306.19		
				Return premium quantity disch'g London		34.13		
							272.06	
				Analysis			56.20	
				Cablegrams, petties, etc			36.46	
				Commissions			1,638.04	9,700.69
				Net proceeds				22,241.45

NOTE.—Loss in weight between mines and delivery at port, 44.186 tons.

A circular letter giving list of 10 cargoes of Florida hard rock phosphate, taken from account sales actually rendered to the company reads as follows:

LONDON, *October 5, 1891.*

We have now the pleasure to annex a list of all the cargoes of Dunnellon hard high grade phosphate so far received, arranged in the order of shipment, which we commend to your careful consideration:

Ship's name.	Quantity (tons).	Per cent. of phosphate on dry basis.	Per cent. of iron and alumina.	Per cent. of moisture in phosphate as delivered.
Elstow	1,950	77.55	2.78	1.32
Salamanca	1,450	79.90	2.33	2.53
Hallamshire	1,472	79.13	2.49	2.02
Louise H	1,200	80.21	2.13	1.24
Winston	1,402	79.95	2.30	1.33
Hessle	2,350	79.37	2.36	1.39
Longhirst	1,714	77.45	1.95	1.65
Navigation	1,938	78.16	2.36	1.52
C. Siegheim	1,780	77.73	2.10	2.03
Reigate	242	80.16	2.09	1.28
Average	15,498	78.96	2.29	1.63

WYLLIE AND GORDON,
European Selling Agents.

An analysis of hard rock and plate rock combined, an unusually fine sample, as made by the Pratt Laboratory, Jacksonville, Florida, is as follows:

CERTIFICATE OF ANALYSIS.

Record No. 1344.

Sample from Trenton district, Alachua county, Florida, received October 5, 1891.

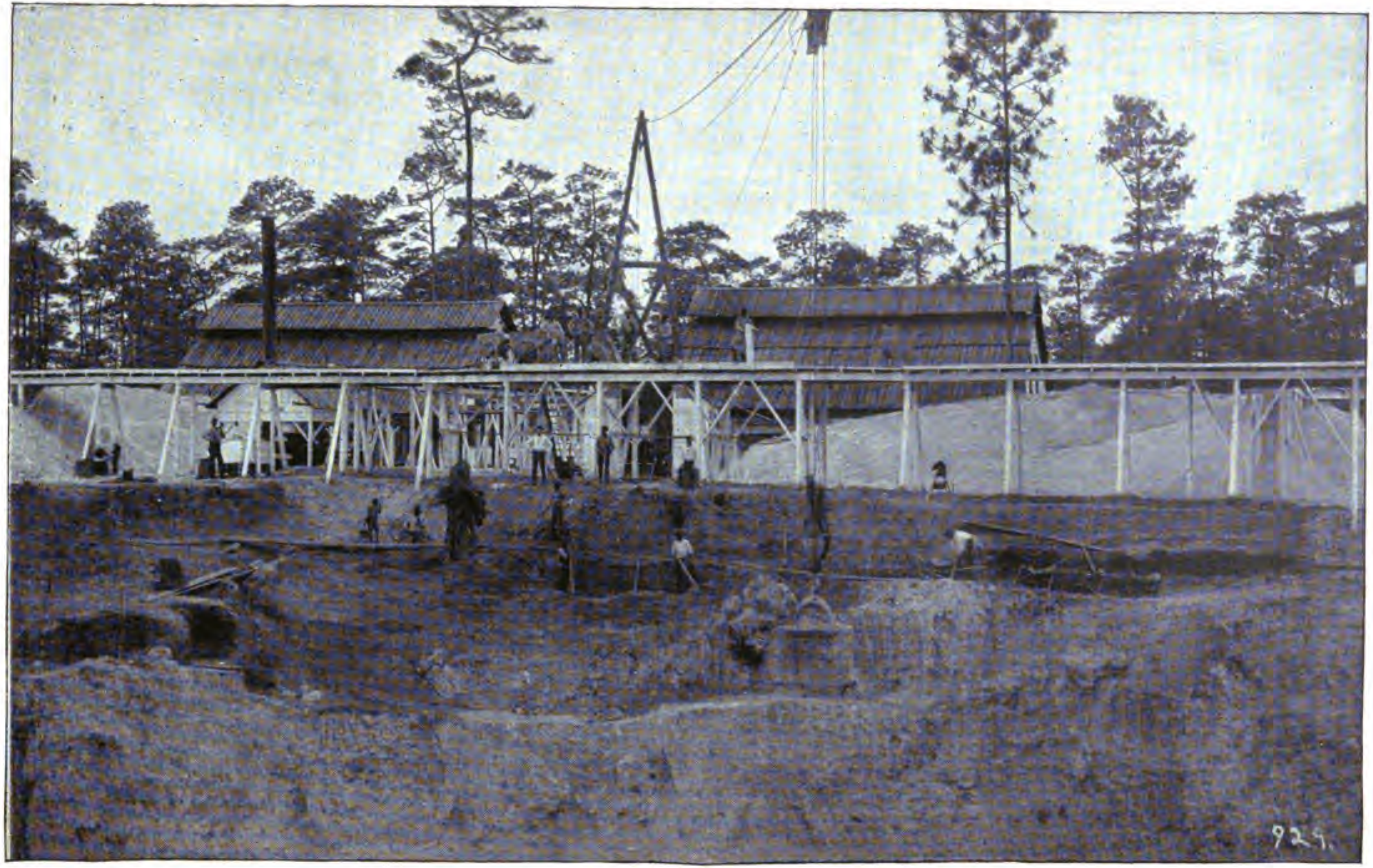
Marked—Average of 2 pounds of fragments ground together:

Constituents.	Per cent.	
Moisture, at 212° F	....	....
Sand and insoluble silicates	....	.80
Iron oxide Alumina	....	2.20
Carbonic acid	....	....
Equivalent carbonate lime	....	....
Phosphoric acid	40.19	....
Equivalent bone phosphate	....	87.73

Respectfully submitted.

PRATT LABORATORY,
N. A. PRATT.

JACKSONVILLE, FLORIDA, *October 6, 1891.*



FLORIDA HARD ROCK PHOSPHATE MINING.
Mining by steam power with the wire cable hoist and trolley system.

Mr. George M. Wells, a phosphate expert and practical miner, who has had years of experience in the South Carolina mines, and who has been until recently the superintendent in charge of the extensive mining operations of the Dunnellon Phosphate Company, gives the following experience and views of Florida hard rock phosphate: Mr. Wells says phosphate mining requires the greatest care and attention, and that every particle, be it boulder or gravel, should pass under the eye of an expert, a clear light and a keen eye being necessary to detect the foreign matter and imperfections; and all this care must be exercised in the mines at the original handling, in order to save waste of labor. The white sand around Dunnellon and the snowy whiteness of much of the phosphate there made the glare very severe upon the eyes. The glare soon affected the eyes of those unaccustomed to it, making them weak and sore. They undertook to overcome this serious difficulty by the use of colored glasses, but these, while relieving the eyes, so confused the colors that they could not select the phosphate with any degree of certainty, and the use of glasses had to be abandoned. In the same mine many formations are found which resemble phosphate so closely that the miner must be always on the lookout to detect the genuine article; again, there are differences of quality which must be considered, separating the high grades, which are taken by the foreign market, from the lower grades, which go to the domestic market; again, some rock runs so low in phosphate, or so high in iron and alumina, that it must go to the dump or waste pile, without any immediate prospect of being utilized. After this separation of grades comes the preparation for market, which requires great care, and must be well done in order to secure the degree of uniformity essential to a proper estimate of the phosphate. By exercising great care a number of cargoes have been secured which averaged about 79 per cent. phosphate of lime. The foreign buyer is very exacting in this respect, and where proper diligence is not exercised the analyzed percentage may be so much reduced as to involve serious loss. After removing the overburden Mr. Wells thinks a net yield of 25 per cent. of the remaining mass will be a good return; the remaining 75 per cent. will be made up of sand-clay, sand, flint, and lime rock, and other foreign matter, with some low grade phosphate running too low to have any commercial value, the labor of separating being too expensive to warrant it. He says it is very difficult to estimate a mine, but in a given superficial area of, say, 1 acre, the phosphate running well and as deep as the mining can be done to advantage and with profit, the mine may in some exceptional cases yield 15,000 to 20,000 tons. As an average, taking all the mines in a given territory, they will run from, say, 200 tons to 8,000 and 10,000 tons per acre. This refers to hard rock; but to some mines it is absolutely impossible to apply any given rule, for in some cases the rock is all hard and comes regularly, while in others the phosphate may be more or less mixed, as already described, with base and foreign matter. Again, in another mine, the matrix and cavities may be actually stuffed with gravel and fragmentary phosphate, which, after washing, screening, and drying, will run up to 75 and 80 per cent. and find a ready market.

As to cost of mining hard rock, Mr. Wells thinks it quite impossible for any one to make a trustworthy estimate.

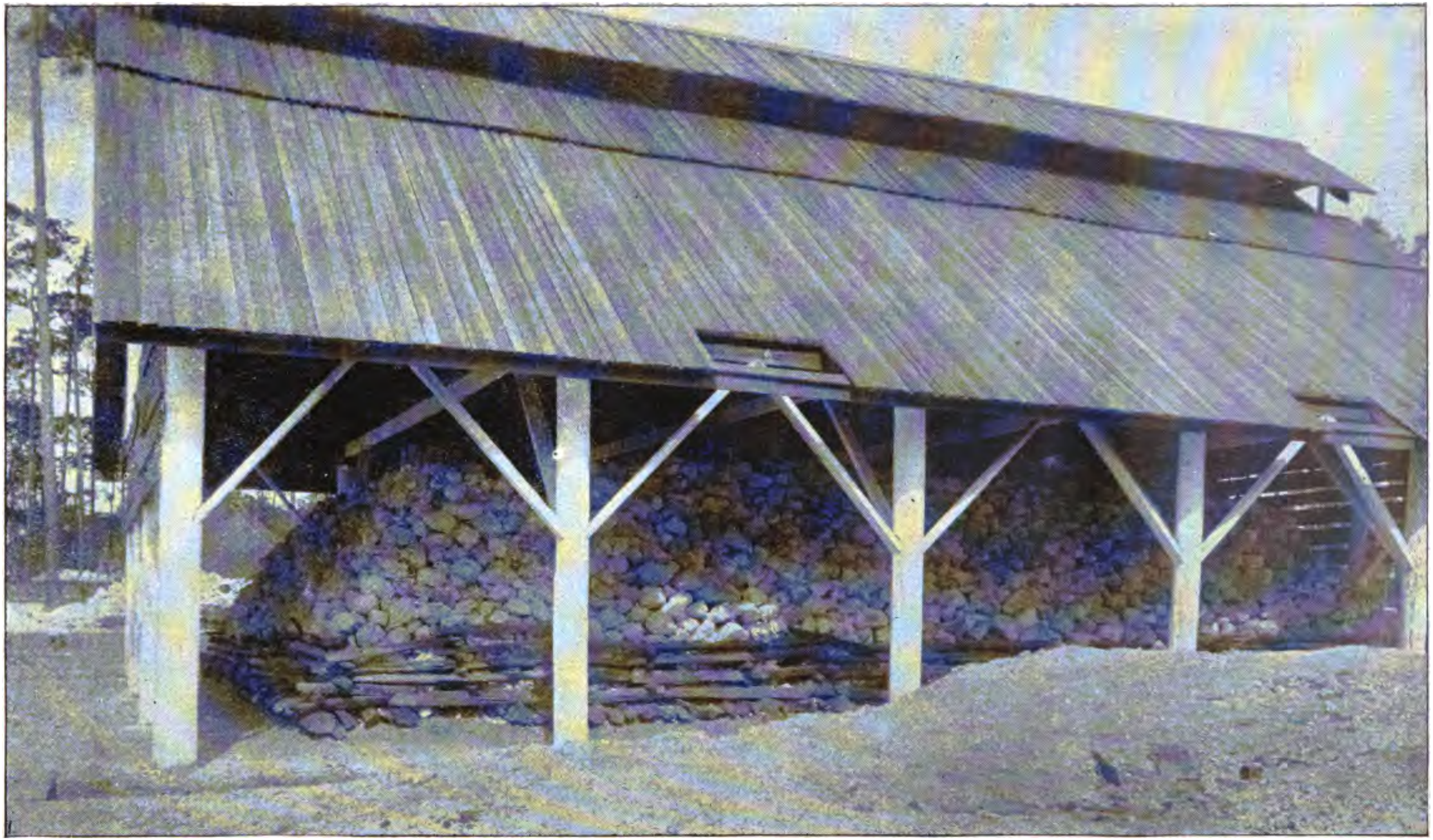
He had opened a mine which lay so favorably—the prospecting having disclosed an abundant deposit close to the surface—that he expected to be able, by the free use of dynamite, to get it out for about $1.50 per ton, but after starting work the presence of hard foreign matter and the time and care necessary to separate the good from the bad, ran the cost up to about $3 per ton.

Gravel screenings.—Intermixed with the hard rock and generally constituting more or less of the matrix, in some cases covering the walls of the mine like so much stucco work and filling the banks so full that it is difficult to understand how they could hold any more, and often overflowing the mine and forming a drift for several acres around it, is found a fragmentary phosphate, or what is now more generally denominated the gravel or gravel screenings, which at first was so lightly esteemed as to be considered of doubtful value and was thrown aside, trusting that at some future time there might be a demand for it. Even the first small shipments, in an experimental way to foreign markets, were not well received, and explanations had to be made why it had been sent in lieu of the boulder product which they expected.

At last, when its true value and importance were generally conceded, it came to the mining companies almost as a gratuity, for it constituted a considerable percentage of the matrix of all hard rock mines and must necessarily be taken out.

Its proper preparation involved the purchase of a steam plant for washing, screening, and drying. Some few still dry it in kilns, but the complete machine plant, including the dryer, has the advantage of requiring but one handling, as in that case it goes directly to the storage room from the dryer. The process may be still further extended and cheapened by loading it into the cars by gravity, when taken from the dump; the entire process, probably, not costing more than 75 cents to $1 per ton.

Of so much consequence has this branch of hard rock mining become, that now nearly all the mines are supplied, or are being supplied, with steam washer plants as necessary adjuncts to their business, and most of the mines are now engaged in working off their accumulated gravel found in the dump. After this is finished it is probable that the two processes—boulder mining by hand and the preparation of the gravel by machinery—will go on simultaneously, or what is regarded as better and in the line of a higher grade of product, the boulders will be passed through a crusher, thence with the gravel through the



FLORIDA HARD ROCK PHOSPHATE MINING.
Drying shed with the boulders heaped upon a crib-work of cord wood preparatory to firing.

washer, etc., and all delivered together in a finished state into the storage room, thus securing at the same time both uniformity in size and analysis. In this condition it also admits of cheaper, and more convenient and expeditious handling at the seaboards by elevators, etc. Several companies are already doing this, and the advantage is so apparent that no doubt all will sooner or later adopt it.

This gravel, varying in size from that of a grain of coffee to about that of a hickory nut, now and then running into fragmentary plate rock, is nothing more nor less than the abraded and fractured particles of the hard rock boulders, which were undoubtedly ground together by some natural cause as yet unexplained, or, as many believe, by some mighty upheaval which once disturbed this peninsula. However that may be, all agree that the gravel is the shattered fragments of the boulder rock. Like the boulder rock the gravel is generally hard, compact, smooth, and heavy. The base matter adhering thereto is almost entirely confined to the surfaces and freely yields to the washing process, through which it is at once raised to a level with the boulder rock in its high percentage of phosphate of lime, and in some cases actually surpasses it.

The gravel, therefore, being substantially the same, it is easy to understand how, by this improved washing and scouring process, it has in point of high grade taken rank with the hard rock boulder itself, both now being sold in market on terms of perfect equality. When the crusher is used and both kinds mingled together, as is now done by the Florida Phosphate Company, the combined product is made to give an average of 80 per cent. phosphate of lime.

This general utilizing of the gravel has put a new phase upon hard rock mining, materially reducing the cost and greatly increasing the yield of the mines.

Plate rock.—As described in another place, the plate rock field is a belt by itself, with the same general trend as the main belt, running from about north-northwest to south-southeast.

It lies almost wholly within Marion county. In extent it is the smallest of all the deposits, being about 30 miles long, with an average width of about 3 miles. The peculiar rock from which it takes its name is plate like, the rock resembling the broken fragments of a stack of plates. The broken pieces are of angular form and vary from 1 to 6 inches in breadth. In thickness they vary from one-fourth of an inch, or even less, to fully 1 inch. The rock is heavy and hard, and is often worn smooth and white like ivory. A clean, sound piece will ring when struck. The prevailing color is cream and yellowish when taken from the mine, but it bleaches rapidly. Occasionally it is found stained like some of the hard rock. If it is borne in mind that this is evidently a drift from the hard rock belt and is the shattered and broken remnants of broken down boulders of laminated phosphate, it will make plainer this description.

Accompanying the larger fragments there are quantities of smaller stuff, shattered and ground into innumerable shapes and in size from that of a grain of rice up to that of a hickory nut. Now and then a small boulder may be found, the largest being about the size of a nail keg. Very little soft phosphate has been found in the plate rock belt. The plate rock proper washes and bleaches quite white and is left in a beautiful mechanical condition. After its breaking up it lost in the percentage of phosphate of lime and gained in iron and alumina; but for this contamination, which comes from the exposure of so much more surface in its fragmentary form, it would grade much higher. By the process now in use, however, considerable improvement has been made. Shipments have averaged 75.63 per cent. phosphate of lime and 2.80 per cent. of iron and alumina.

Plate rock offers great opportunities to mechanical appliances, and no doubt the improvements, which, with experience, may be reasonably looked for, will raise the standard still higher. The difficulty, evidently, lies in the adhering matter, and the scouring, washing, rinsing, and drying process through which it is carried operates both ways, at the same time raising the percentage of phosphate and reducing that of iron and alumina. A demonstration of this may be seen in the following analyses of unwashed and washed plate rock:

PERCENTAGES OF VARIOUS CONSTITUENTS IN UNWASHED AND WASHED PLATE ROCK.

Constituents.	Unwashed.	Washed and dried.	Difference.
	Per cent.	*Per cent.*	*Per cent.*
Phosphoric acid	34.20	36.94	2.74
Bone phosphate of lime	74.67	80.63	5.96
Iron and alumina	4.32	1.45	2.87

Owing to the singular formation of the rock, the mining must be done by hand. A cable hoist and trolley receives it when mined, and from the cable hoist it is dropped into a large hopper, thence by gravity it passes into a trough 30 feet long and about 3½ by 4 feet in width and depth, filled with water, in which revolves a log-washer or screw conveyer, which agitates, pushes, and shoves the entire mass up a slight incline, and against a powerful current of water, by which rubbing process it is thoroughly scoured and cleaned. From the log-washer it goes into a cylinder-washer about 16 to 24 feet long and 4 feet in diameter. This is filled with teeth, which agitate it, and with angular plates, which carry it forward into another cylinder-washer or rinser, and thence to the drier, after which it is ready for shipment. This plate rock formation is both peculiar and wonderful, and simply as a matter of interest and curiosity is well worth a visit from those interested in geological research or natural wonders.

As the overburden, which may be from 2 to 10 feet deep, is removed, gradually there comes into view the rounded projections of water-worn limestone, dotted all about and of various sizes, and in shape resembling somewhat the surface of inverted cups and saucers; but as the work of removing the overburden proceeds they develop into the general shape of a sugar loaf. Usually they are solid, but frequently they contain hollows with a clean, smooth cut surface like that of a bored well, and from 18 inches to 3 feet or more in diameter and from 8 to 25 feet deep. These well-like holes are filled with the phosphate and its matrix of sand or clay. One very deep pocket of this sort was seen near Anthony, out of which 125 tons of washed phosphate had been taken. Often these spires are grouped together and the large intervening spaces form pockets. In and about this erratic formation is found the phosphate drift, which, intermixed with the sand or clay, settled into a pretty well defined stratum, which must be worked by picks, spades, and shovels, and in close places with the hands. The sand matrix is readily washed out, but the clay is more obstinate, often forming into balls, from the size of a marble to that of an orange, in the washer or revolving cylinder. The more it is rolled the harder it gets, and must be picked out by hand. There appears to be no particular affinity between the phosphate and limestone, and there is no commingling, the line of demarcation being distinct. From its accessibility and limited area, the plate rock field has been more carefully prospected than any other, and the lands located with more discrimination. For that reason it is believed that the plate rock phosphate area will reach 15 per cent. of the total phosphate area. The yield is about 2,500 tons per acre. Near the town of Anthony, in this belt, ten steam plants are now in operation. The largest of these, that of the Compagnie des Phosphates de France, costing $40,000, with an output of 75 to 100 tons per day, has just commenced work, and by its powerful and improved machinery has already raised the quality of its product to about 78 per cent. phosphate of lime, demonstrating the possibilities of plate rock as already foreshadowed in this report. It is quite safe to say that the maximum has not yet been reached.

An analysis of plate rock by its subdivisions, by O. Grothe, Ph. D., of Ocala, Florida, follows:

Sample 1 was of large plates, constituting one-tenth to one-fifth of total; sample 2 was of the next larger fragments, constituting about one-tenth of total; sample 3 was of the next size of fragments, constituting one-tenth to one-fifth of total; and sample 4 was the very fine pebbles or fragments, constituting one-half to three-fourths of total.

The result shows the increase of percentage of iron and alumina and moisture carried with the increase of surface exposed, and a corresponding reduction in the percentage of phosphate of lime. By the use of improved machinery it is hoped to raise the average of phosphate of lime and reduce that of iron and alumina.

ANALYSES OF FOUR SAMPLES OF PLATE ROCK.

Constituents.	Sample 1.	Sample 2.	Sample 3.	Sample 4.	Average.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Moisture	1.00	1.05	2.07	3.75	1.97
Phosphate of lime	77.54	75.29	74.05	70.03	74.23
Oxide of iron and alumina	2.00	4.89	4.32	6.04	4.31

Sample 3, by dry basis, gave 75.56 per cent. of phosphate of lime and 4.41 per cent. of iron and alumina, while sample 4, by dry basis, gave 73.49 per cent. of phosphate of lime and 6.27 per cent. of iron and alumina.

An analysis by B. F. Gibbens of one shipment of plate rock phosphate shows the following percentages of phosphate of lime and iron and alumina:

ANALYSIS OF ONE SHIPMENT OF PLATE ROCK.

Constituents.	Per cent.
Phosphate of lime	75.63
Iron and alumina	2.80

Immediately following is given an estimate of the running expenses for one day of a plate rock mine producing 30 tons per day and using machinery:

RUNNING EXPENSES PER DAY OF A PLATE ROCK MINE.

Occupation.	Number of men.	Daily rate of pay.	Total wages.
Manager	1	$4.00	$4.00
Mechanical engineer	1	3.00	3.00
Fireman	1	1.25	1.25
Trolley tender	1	1.25	1.25
Mine boss	1	1.50	1.50
Laborers	10	1.00	10.00
Total labor	15		21.00
Six cords of wood at $2 per cord			12.00
Oil, packing, waste, etc			1.00
Total running expenses for one day			34.00

Composite phosphate.—The composite belt is so denominated because the phosphate there found is of two kinds, the hard rock boulders, as found in the hard rock belt proper, though in smaller quantities, and drift surrounding the boulders, often covering many acres, composed of plate rock and gravel screenings, as described elsewhere. At Luraville, in Suwannee county, where it was first discovered, this singularity was marked. South of Luraville, on the Steinhatchee river in Lafayette county, the same general features are observed, though the land lies lower and the phosphate is somewhat adulterated with sandstone, iron, etc. In the Trenton region, in the western part of Alachua and Levy counties, the drift covers large areas; the boulders are not so pronounced as at Luraville, yet they are as large as a flour barrel, and test pits showed good hard rock; but what the deposits lose in the boulders they make up in the drift, which in one case is said to cover 70 acres, though this is exceptional. The Luraville and Trenton deposits are both of good quality.

The percentage of area is fair, and the yield is placed at an average of 3,000 tons per acre.

With boulders and drift formation in the same land, the cost of mining should not be expensive, for machinery can be and is utilized with great advantage and to the satisfaction of those having charge of the mining operations in this field.

Analyses of samples of composite phosphate from the Trenton region in Alachua county, follow:

ANALYSES OF SAMPLES OF COMPOSITE PHOSPHATE FROM TRENTON REGION, ALACHUA COUNTY, FLORIDA.

Constituents.	Laroux chemical laboratory, 9 samples.	Shepard's laboratory, 1 sample.	B. F. Gibbens' laboratory, 2 samples.	Average.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Phosphoric acid	35.65	....	....	....
Bone phosphate	77.86	82.79	80.26	80.30
Oxide of iron and alumina	2.20	1.83	2.04	2.03

Soft phosphate.—The soft phosphate is found in both clay and sandy land and in the form of bed-like pockets, and again as a part of the matrix of the several classifications of hard rock, but most frequently of the hard rock boulder. In consistency it closely resembles fine clay, is usually moist, compact, and heavy, and there being very little waste the yield is large.

Like the hard rock, it is found in several colors. White, cream, yellow, brown, and gray are found, but the predominating color is white. Like all other phosphates, no matter what the original color may have been, it all bleaches more or less to a white or light gray. To the touch it is soft and agreeable. The lower grades are adulterated with sand and clay, and are more heavily charged with iron and alumina. In weight it is somewhat variable, though the most of it is quite heavy, but there is a kind which comes out in lumps, which, both in its color and exceeding lightness, resembles magnesia. In quality it is more fluctuating than any other kind, ranging from 40 to 80 per cent. phosphate of lime, but will average about 65 per cent. It shows from 3 to 14 per cent. of iron and alumina, the average being about 7 per cent.

One kind has been found that seems to be in a transition state. In the mine it is soft, but tenacious, and can be cut with a knife like soapstone. With a few days' exposure it becomes hard, can be broken into lumps, and shovelled about like coal. It is of fine quality and can be burnt and run in with the hard rock. There is another variety which is chalk-like and granular, and predisposed, like some of the softer kinds, to disintegrate and fall apart in handling. This is claimed to be especially fine for use in the raw state. Experience has not yet demonstrated the difference in solubility and available phosphoric acid, but it is generally believed that it gives better results than any other kind of raw phosphate, or even ground bone.

This soft phosphate in its several varieties, which are probably more the result of soil stain and adulteration than anything else, and which in the form of pockets, down among the boulders, or as a matrix, occur so frequently in hard rock mines, was in the earlier days of Florida mining entirely rejected, tens of thousands of tons having been thrown aside as worthless and unmarketable. The fluctuations in quality, as to percentage of phosphate of lime and iron and alumina, were against it, and the manufacturer found it difficult to reduce it to the desirable mechanical condition for his trade, claiming that manipulation made it adhesive and paste-like.

In the meantime the farmers, truckers, and fruit growers of the state were giving it a practical trial as a natural fertilizer in its raw state; and the consensus of opinion is that it is a manure of surpassing virtue, and for the purpose of restoring exhausted lands and old worn out farms, is the cheapest and at the same time one of the best of fertilizers.

Dr. Pratt says of this soft phosphate, "It will come into general use as a cheaper fertilizer, to be used in greater abundance and with great permanent benefit to the land."

Extended inquiries and observations, covering a number of counties, appear to demonstrate another fact—its value as a simple application or dressing to a growing crop.

During the protracted drought of 1891, it was noticed that the trees and crops treated with soft phosphate endured the trying ordeal much better than others, whether manured or unmanured. The increase in the yield of cotton, in test rows manured with soft phosphate, was marked, and proved the phosphate to be better than animal manure and standard fertilizers, and the result could only be accounted for by the property the phosphate possesses for absorbing moisture. It is estimated that the rock phosphate will take in from 5 to 15 per cent. of moisture, while the soft, says Dr. Pratt, will absorb from 30 to 40 per cent., which explains its apparent superiority. If, as surmised, the phosphate attracted and continued to attract, and treasured up sufficient moisture to carry these crops safely through the drought, further experiments should be instituted in order that the truth may be definitely ascertained.

The French farmers, who are among the most successful and generally prosperous of any in the world, use more than 200,000 tons of ground raw phosphate per annum. It is also used in Germany and other countries with advantage. Their practice should at least encourage the planters and farmers of our own country to give it a fair trial.

The agricultural experiment stations of the several states can be of great service in the matter, and a series of experiments by them would soon establish the true value of soft phosphate. These experiments should test its value in the raw state, both alone and in combination with muck, barnyard and other manures, potash, etc.

Soft phosphate has been located in considerable quantities independent of that referred to in the hard rock mines, but it was generally condemned owing to ignorance of its real worth. Miners are just beginning to give it the attention it deserves. The limited number who engaged in mining it have gradually worked up a very good home demand, which is steadily increasing, and judging by the results already brought about and the manner in which it is growing in popular favor at home, it is no doubt destined to occupy a much wider field.

Soft phosphate is usually mined with picks, spades, shovels, and horse carts and closely resembles clay in handling, being about as heavy and as hard to dig. This is a simple and not very expensive process. When a deposit is struck, it usually runs regularly and yields enormously.

The yield per acre, inclusive of the large quantities taken out of the hard rock mines, is placed at 5,000 tons, which is believed to be a reasonable estimate.

In the land pebble field the soft phosphate is of a different character from that already described. The matrix is a soft, porous marl or lime rock impregnated with soft land pebble in considerable quantities, through which the entire mass has probably become phosphatized. It is readily worked, yields well, and has given good results wherever tried.

Analyses of various samples of the soft phosphate now being marketed, follow:

ANALYSES OF VARIOUS SAMPLES OF SOFT PHOSPHATE.

Constituents.	Pratt's laboratory. Samples from Hernando county.	Serge Malyran's laboratory. Samples from Marion county.	B. F. Gibbens' laboratory. Samples from Levy county.	Average of all samples.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Moisture	.20			
Combined water	1.75			
Silicic acid	26.90			
Phosphoric acid	29.49	27.93		
Equivalent to bone phosphate	64.38	63.16	49.66	59.06⅔
Alumina and iron oxide	2.75	4.45	14.62	7.27⅓
Magnesia	1.64			
Alkaline chloride	.50			
Carbonic acid and fluorine, and loss in analysis	2.49	6.55		
Magnesia, soda, etc		8.14		
Phosphoric acid soluble in ammonia citrate	1.15			
Phosphoric acid soluble in bicarbonate of soda	1.19			
Phosphoric acid soluble in carbonated water	1.21			

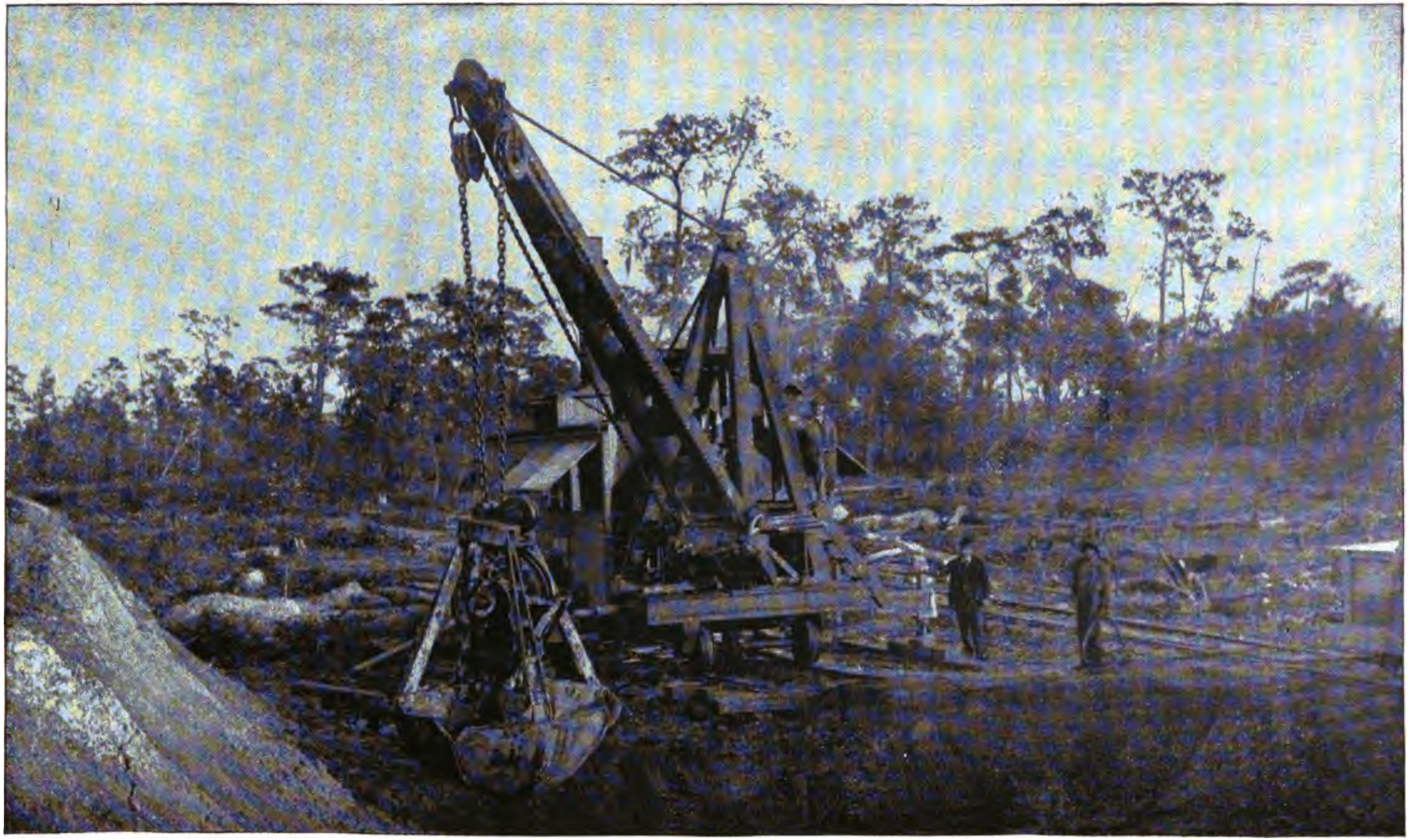
The following table showing the increase in the soft phosphate sold in Florida for home use, since its introduction in 1890, may be of interest. This phosphate is either applied directly to the soil in its raw state, or composted with muck, barnyard, or other manures. In addition to this home consumption, a quantity has been shipped out of the state for experimental purposes. This phosphate is simply dried, or dried and ground, and is sold on the basis of a ton of 2,000 pounds.

QUANTITY AND VALUE OF SOFT PHOSPHATE SOLD FOR CONSUMPTION IN FLORIDA IN THE YEARS 1890, 1891, AND 1892.

Year.	Quantity sold (tons of 2,000 pounds).	Average price per ton.	Total value.
1890	1,500	$5.00	$7,500.00
1891	5,544	5.47	30,306.50
1892	6,180	5.49	33,950.00
Total	13,224	....	71,756.50

Land pebble.—The land pebble phosphate is a formation distinct from the others. It is pebbly, as its name indicates, is of small size, and is somewhat lighter in weight than other forms. In color it varies from cream or yellow to slate, brown, or gray. When well bleached much of it is snow white, and of varied degrees of hardness. This pebble runs in size from what is called pin head up to the size of a pea or bean, and even larger. Often the soft pebbles have run together, forming conglomerate balls of various sizes and shapes, the largest measuring several inches in diameter. This applies to the drift. In that of animal origin the fossils are of all sizes, from the tiniest shell-fish or tooth to the remains of the sea-cow, mastodon, or elephant. Through all the formations here, as elsewhere, but more generally here, sharks' teeth and other fossil remains are constantly met with. After close observation the conclusion has been reached that they are merely incidental to the several deposits, but not the direct cause of them, as appears to be the case on the Sopchoppy river in Wakulla county, and also on the Caloosahatchee. These fossil remains, though they must have been quite generally distributed over the entire peninsula, have almost wholly disappeared, save in these phosphate fields, and occasionally in the beds of rivers. Even in the limestone formation only the casts of shells bear witness of their former existence. This leads to the conclusion that to the natural affinity between the fossil bones and the phosphate, and the preservative properties of the phosphoric acid, we are indebted for the large quantities of such remains found intermixed with the phosphate. But large as are the quantities of fossil remains, not enough have been seen in the entire state to account for a fraction of the phosphatic deposits discovered.

This pebble came as drift, and after removing the overburden,



FLORIDA LAND PEBBLE PHOSPHATE MINING.
The clam-shell dipper in operation.

which is from 2 feet to 10 feet deep, the pebble-bearing stratum is reached.

The matrix is of clay, sand, and occasionally a soft kind of rock, but whichever it is, the pebble is found well distributed and thoroughly incorporated with it. In some places the deposit is richer than in others, but little difficulty is found in following the lead, as long as the pebble holds out, for the tendency of phosphate, even in drift, is to concentrate and run together where possible.

The sand matrix gives way readily, but the clay is generally stiff and tenacious. The rock, when dried and crushed, yields up the pebble without much trouble.

In mining the pebble, the stumps and roots of trees, lime rock, and other foreign substances are removed to one side, and the mass that is left is dug down with picks and spades, and conveyed, just as it is shovelled up, dirt and all, to the plant, where it is dumped into a disintegrator and afterwards put through one or more washings. Thence it goes to the drier, from which it passes through a screening process and is finally landed in the dry bin.

The thickness or depth of the phosphate deposit varies considerably. Some claim a very great depth; but for practical working, the experience of miners places it generally at from 3 to 6 feet, sometimes a little more. The dirt yields all the way from 10 or 15 per cent., to as much as 66 per cent. in exceptional cases where pockets have been formed. For paying dirts, 20 per cent. is considered as about the minimum yield, and 30 per cent. is a very good average.

A number of analyses of the pebble gave an average of 67.07 per cent. of phosphate of lime, and 3.78 per cent. of iron and alumina.

Some of the largest and finest plants in the state are to be found in the land pebble belt, and they have succeeded, under the direction of intelligent and skilful management, in increasing the percentage of phosphate of lime, and reducing that of iron and alumina.

A novel system of mining was adopted at Phosphoria by a large English company. Phosphoria is in the high pine woods, 140 feet above the level of the Gulf. This company built a fleet of barges which were 60 feet in length, about 20 feet beam, and 5 feet depth of hull. One of these barges was supplied with a powerful steam shovel of the size and pattern used in harbor improvements. This was set to work, and in a little while the springy waters, with which the land was charged, began to pour in, and within a short time there was room and water enough to launch and float the barge. The work was then continued until the canal was sufficiently long to accommodate the fleet, with the prospect of quite a navigable stream in a year or so. The plant of this company is on such a scale that it can take everything the shovel dumps into the hopper. The dredge follows the drift of the deposit, excavating the phosphate, and securing artificial navigation at one and the same operation.

The Bartow Phosphate Company is using with great success the steam clam-shell folding dipper, operated from a car on a railroad track, which is prolonged over the land laid out to be mined. The folding lever, to which the 5-ton dipper is attached, works on a pivot and moves over a semicircle of about 25 feet. On one side of the excavation made, the overburden or dump is discharged, and on the other, the workable dirt is deposited in cars on a side track. As the work progresses the steam shovel retires, leaving behind it an enormous ditch, resembling a canal, which rapidly fills with water.

Where there is nothing but a sandy matrix, a centrifugal pump has been substituted for the dipper. A powerful stream of water is played upon the matrix, with the purpose of disintegrating the mass as it lies, then another pump raises it, after the manner of the river mining. In clay or rock matrix this method has not given satisfaction, though experiments are still being made in that direction.

Land pebble mining offers a wide range for inventive genius, and improved machinery is being introduced as experience and experiments warrant a change.

This land pebble is found chiefly in Hillsborough, Polk, and De Soto counties, with considerable indications in Manatee county; and as may be seen from the map, the field is of great magnitude, and a most important and valuable accession to the phosphate supply. It shares with the other fields in the favorable consideration of experienced prospectors and operators.

Bartow, a thriving south Florida town, is the business centre of the land pebble belt, and Tampa the principal shipping port. Like all phosphate lands, the area of land pebble varies much, depending upon the care and judgment exercised in its selection. The yield in some cases will be found enormous; but for a located plant, working all the paying dirt in reach, 2,250 tons per acre will be found a fair average. As land pebble mining admits of a free use of machinery, the cost should probably be the lowest, save that of the river pebble.

ANALYSES OF LARGE AVERAGE SAMPLES OF LAND PEBBLE SENT TO ENGLAND.

Constituents.	Voelcker.	Cannon and Newton.
	Per cent.	*Per cent.*
Moisture	.45	Dried at 212°
Organic matter and water of combination	1.55	....
Phosphoric acid	33.07	33.26
Lime	45.82	43.86
Oxide of iron	1.19	1.80
Alumina	1.63	
Magnesia, etc	5.37	....
Carbonic acid	1.64	2.00
Insoluble silicious matter undetermined	9.28	10.21 8.87
Total	100.00	100.00
Equivalent to tribasic phosphate of lime	72.19	72.61
Equivalent to carbonate of lime	3.72	4.54

The average result from 36 analyses of bulk samples (of a half ton each), taken from various parts of the deposit, was 67.35 per cent. of phosphate of lime and 2.27 per cent. of oxide of iron and alumina, as analyzed by C. Kuberger of Germany.

ANALYSES OF VARIOUS SAMPLES OF LAND PEBBLE FROM POLK COUNTY.

Constituents.	L. R. Vorce, B. S., 6 samples.	L. R. Vorce, B. S., 23 samples.	Pratt's laboratory, 8 samples.	Average.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Phosphoric acid	31.52			
Phosphate of lime	68.97	67.07	67.69	67.91
Iron and alumina	3.13	3.78	2.76	3.22

Immediately following are shown the estimated running expenses per day of a land pebble mine using machinery and producing from 40 to 50 tons per day:

RUNNING EXPENSES PER DAY OF A LAND PEBBLE MINE.

Occupation.	Number of men.	Daily rate of pay.	Total wages.
Manager	1	$4.00	$4.00
Steam shovel engineer	1	2.50	2.50
Steam shovel fireman	1	1.50	1.50
Steam shovel craneman	1	3.50	3.50
Tram car hands and loaders	3	1.50	4.50
Washer feeder	1	1.50	1.50
Washer engineer	1	3.00	3.00
Washer fireman	1	1.50	1.50
Dry bin hand	1	1.50	1.50
Waterman	1	1.50	1.50
Extra hands	2	1.50	3.00
Total labor	14		28.00
Ten cords of wood at $2 per cord			20.00
Oil, packing, waste, etc			2.00
Total running expenses for one day			50.00

River pebble.—The river pebble is so denominated because it is found in the beds of rivers and their tributaries. It was first discovered in Peace river, but has since been found in the Alafia, Manatee, Miakka, Caloosahatchee, and Withlacoochee on the Gulf slope, and in the Black river on the Atlantic slope. The Peace, the Alafia, and the Black river deposits are of the same general type, and are now generally believed to have had their origin in the land pebble, which it much resembles in shape and size, though it is generally smoother, and grades down in size the further it is found from the source of supply. This is due, no doubt, to abrasion and wear from being so often moved in great bodies by the annual floods and changes of the channel, as well as the erosion from the never ceasing flow of the river currents. In size it varies from less than that of a broken grain of rice up to that of a pea or bean, and is often as large as a hickory nut, though a pea or bean more nearly approaches the average size. Mixed with the mass may be found large quantities of fossil bones and teeth, varying in size from a delicate, ivory-like point almost as sharp and not much larger than a needle, up to the tusk of a prehistoric elephant, 7 feet long. The shape is irregular, being sometimes round and nodular, sometimes flat and kidney shaped, and sometimes jagged and angular with rounded points and corners. In color it is gray, brown, slate, and blue-black, the blue-black being the most common.

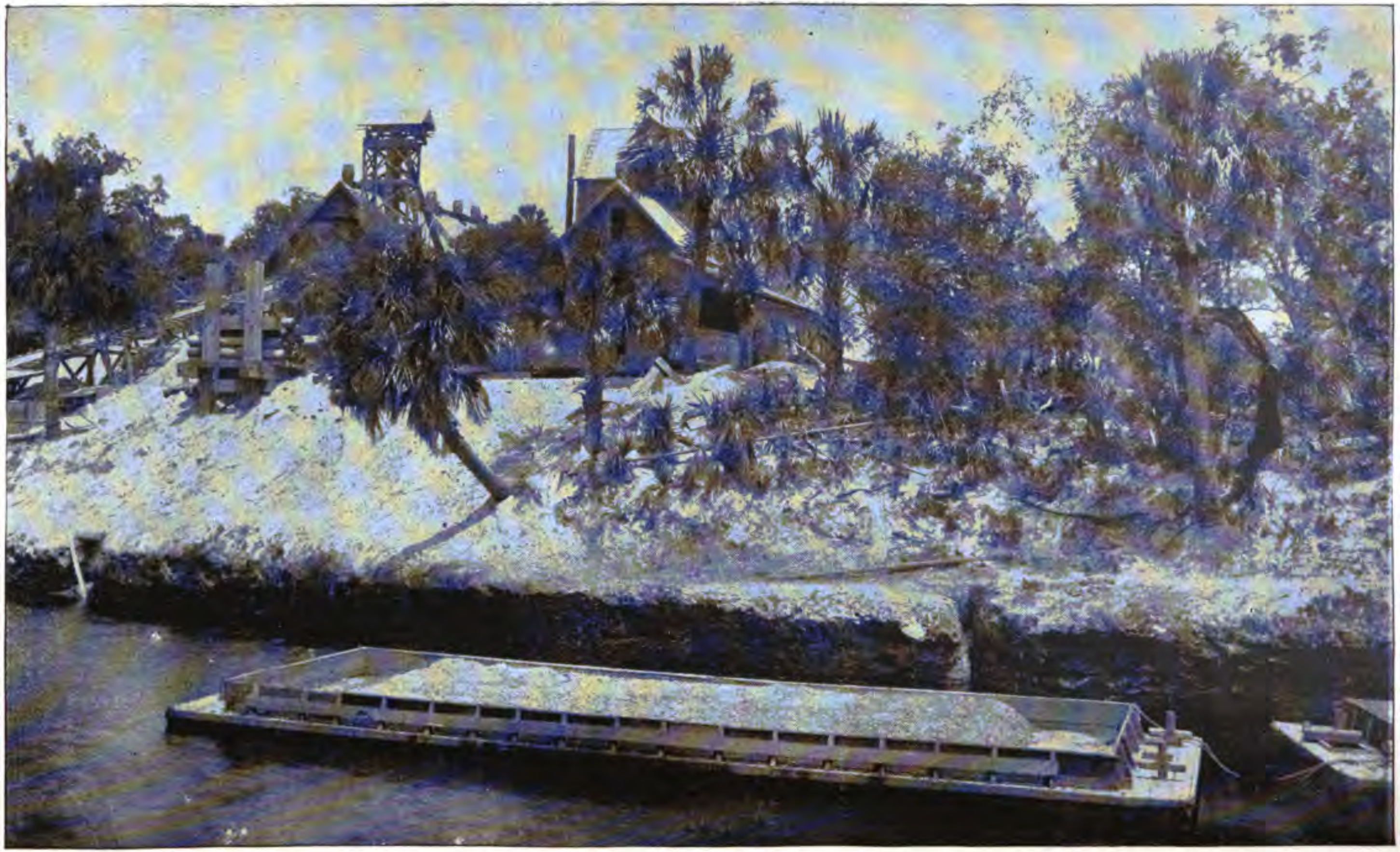
The marked variation in color is in some way connected with the action of the water, for whenever it has been submerged the color darkens, being the darkest in the rivers where it has lain the longest. Some attribute it to the tannic acid drawn from vegetation by the water. To whatever it is due, the stain or dye with which the river pebble is colored is most enduring, not being eradicated even by the drying process in which it is made red hot.

The rapid current of the Peace river has often cut off points and elbows and thereby changed its bed. In prospecting at some distance from the present stream, with a heavy forest growth upon the land, the old river bed may be readily distinguished by the stained and discolored pebble, which, notwithstanding the lapse of time, has brightened little more than a shade.

The river pebble is heavier and harder than the land pebble. This also must be attributed to the petrifying action of the water. Chemically, the pebble has been reduced both in phosphate of lime and iron and alumina. The average analysis of well prepared river pebble shows about 62 per cent. of phosphate of lime and less than 3 per cent. of iron and alumina. It has the advantage of running more regularly than any other kind of phosphate, and its superior mechanical condition is highly valued by the manufacturer. This pebble is not found distributed continuously in the beds of the rivers, but finds lodgement in the basins, holes, and cavities cut in the stiff clay, marl, and soft limestone, in the bends and eddies, and in the great shoals that form here and there like sand bars in other streams. It is said that more than 5,000 tons were taken from one bar, which was estimated to be 18 feet thick and 200 feet long, but these rich bars are found only occasionally.

In addition to the accumulation of centuries, now found in the beds of the rivers, the yielding banks are continually contributing more or less to the general stock. Frequently the dredges find the lead of an ancient river bed, and follow it into the banks as far as the growing trees will allow.

The Withlacoochee river runs through the hard rock belt, and the pebble mined in that stream is clearly the fractured and abraded fragments which correspond with the gravel screenings already described. From time to time it has been swept into the river, where it has become waterworn and undergone a change of color somewhat similar to the Peace river pebble. Owing, however, to its hardness the color, instead of being so black, is often of a dark greenish hue.



FLORIDA RIVER PEBBLE PHOSPHATE MINING.
A plant on Peace river.

The pebble found in the Caloosahatchee is largely of animal origin, and appears to be younger in point of age.

As in the other rivers, fossil bones and teeth of many sorts and sizes are found in abundance.

River mining is carried on almost wholly by machinery, and requires more skilled and less unskilled labor than any other kind. Instead of the dipper, the steam dredges are supplied with an 8 or 10-inch centrifugal pump, attached to which is a flexible suction pipe, suspended from the end of a boom rigged to a mast, and swinging over a semicircle of about 20 feet at the bow of the dredge. By means of guide ropes and pulleys one man works this with ease. This powerful pump raises several thousand gallons per minute. It is estimated by some, that with the water, it will raise 15 per cent. of solid matter, and that, of the solid matter, for each 8 or 10 tons so raised, one ton will be pebble phosphate.

The pump can raise anything not too large for the suction pipe. The pump discharges into a revolving wire screen about 10 feet long and 4 feet in diameter on the upper deck of the boat. This screen separates the pebble from the base material. The pebble comes out thoroughly washed, and is delivered into a lighter, moored alongside of the dredge, while the water and waste material, which is principally sand, is carried through a 12-inch waste pipe the full length of the boat and discharged on whichever side may be most convenient. As the lighters are loaded a small steam tug takes them in tow and delivers them at the plant, where an elevator carries the pebble to a tower or wet bin, from which it is carried, usually by gravity, to the dryer. When dried the pebble is again taken by an elevator, passed through several screenings, and then deposited, being in a very fine merchantable condition, in the dry bin or storage room, from which it is carried to the cars by gravity, where several hands shovel it about and level it as it is loaded. Thus the loading is made a very simple operation. A first class river pebble plant may cost all the way from $10,000 to $75,000, or even more. This includes tugs, lighters, etc. The wear and tear on the machinery is great, owing to the dust and sand cutting out bearings and wearing away other working parts; but after the establishment of the plant the cost of river pebble mining is the cheapest known.

After the discovery of the river pebble, the state undertook to exercise its sovereign rights over these rivers as being a part of its navigable waters, and by law imposed a royalty on all river mines. According to the classification under said law, the following royalties were to be paid on all phosphate taken from the rivers of the state: On phosphate not exceeding 55 per cent. of bone phosphate, 50 cents per ton; on phosphate exceeding 55 per cent. and not exceeding 60 per cent. of bone phosphate, 75 cents per ton; and on phosphate exceeding 60 per cent. of bone phosphate, $1 per ton.

However, prior to the assertion by the state of this right to impose a royalty, individuals and companies had bought up the lands on both banks of these several streams, with the purpose of controlling the riparian rights to the river beds, under the general law. As the rivers were generally narrow, and only in a few places had been meandered by the United States survey, issue was joined by the companies, who declined to pay royalty on any save the meandered territory. This the state refuses to concede, and the matter is now in litigation. This does not interfere with the mining operations, as the companies have given bond, are generally responsible concerns, and keep a correct account of the number of tons mined and shipped. Should the state be sustained, the extent of river mining territory will be about as follows:

	Linear miles.
Peace river	146½
Alafia river	17½
Black river	14
Caloosahatchee river	30
Miakka river	15
Manatee river	10
Withlacoochee river	30
Total	263

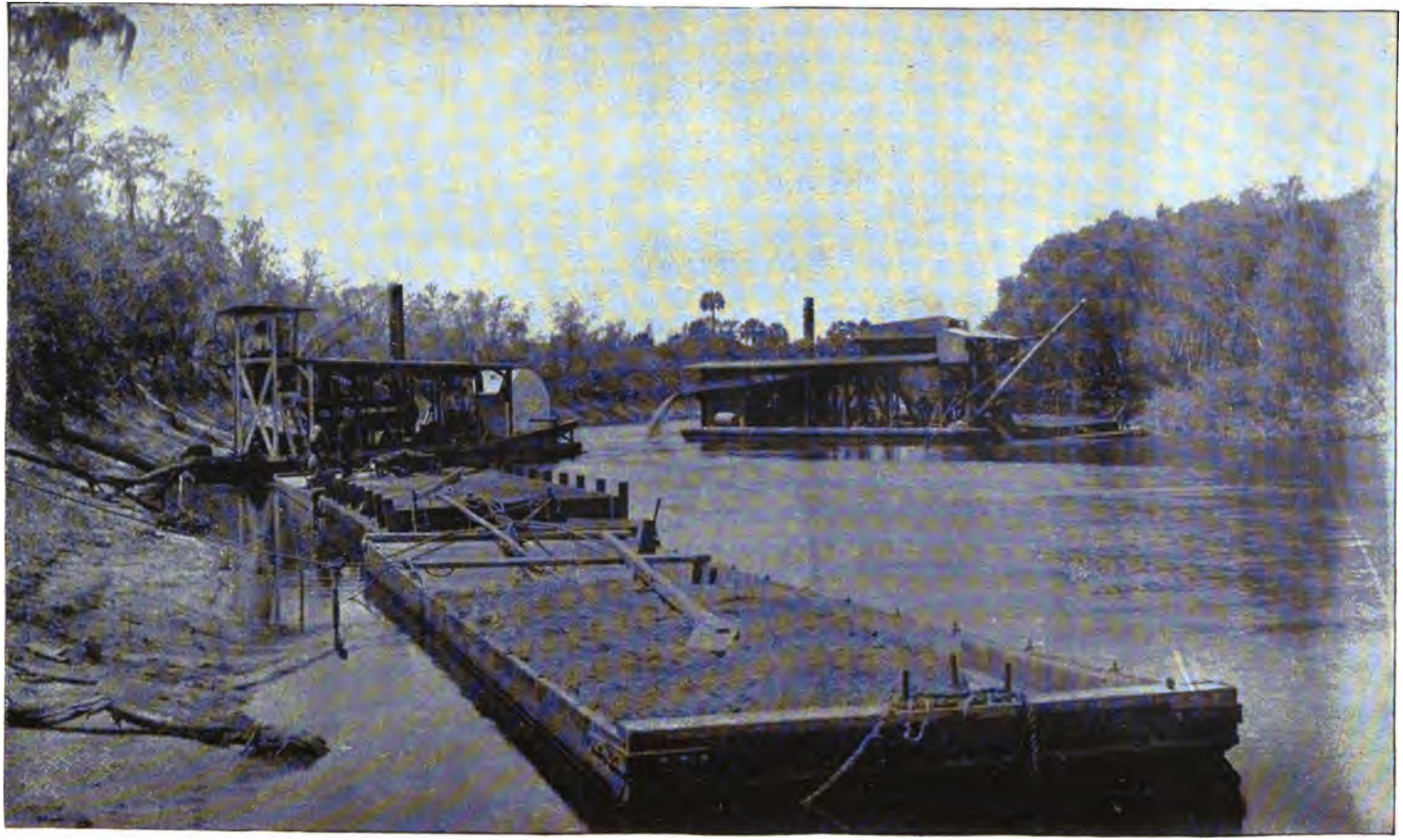
The estimate of yield is based partly on observation of the impression made on river territory already mined for a considerable period, and to which the dredges have returned a second time, and partly upon the average of 1,000 tons per acre, as computed by some for river mining. On this basis the 263 miles of river, allowing a general average width of 35 yards, would give about 3,347 acres, and, deducting 25 per cent. for unworkable and unprofitable territory, we will have 2,510 acres, which, at the rate of 1,000 tons per acre, will give a prospective aggregate yield of something like 2,500,000 tons.

Objections may be urged against this and other estimates given in this report that they are not sufficiently specific.

In answer it may be said that this is the first time anything approaching a definite estimate has been attempted, and that generalities are here dealt in as little as practicable. Hitherto, where writers attempted any description of the extent of the several fields, they have used such sweeping expressions as "exhaustless," "no bottom," "no end to it," and "the entire state is underlaid with it," and the average yield per acre has been placed by them at such fabulous figures that, to say the least, they were gross exaggerations, unwarranted by the facts.

The estimates herein given are based upon something tangible at least, and are intended only as an approximation to the true result as it may be revealed by time and experience.

Their comparative accuracy and reasonableness are based upon the experience of a number of practical miners and upon many months of painstaking observation, including measurements of ground upon which the several kinds of mining had been done and the ascertainment of the actual quantity of phosphate taken therefrom.



FLORIDA RIVER PEBBLE PHOSPHATE MINING.
Steam dredge with centrifugal pump at work.

The scope of this investigation is intended to apply only to the workable deposits, which can be mined with profit from a strictly economic and practical standpoint.

Immediately following are given various analyses of the river pebble phosphate from the Peace river district:

ANALYSES OF SEVERAL CARGOES OF RIVER PEBBLE PHOSPHATE.

Constituents.	Cargo of 2,000 tons.			Cargo of 1,000 tons.	
	Voelcker.	Dyer.	Shepard.	Dyer.	Teschemacher.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Phosphoric acid (dry basis)	28.03	27.91	28.00	28.62	28.75
Equivalent to tribasic phosphate of lime	61.20	60.93	61.12	62.48	62.76
Lime	40.95	41.52	41.21	42.56	43.90
Oxide of iron	.84	1.01	.80	.81	2.25
Alumina	.93	1.56		1.59	

An estimate of the running expenses for one day of a river pebble mine, using machinery and two dredges, with a product of 75 to 80 tons per day, is also given:

RUNNING EXPENSES PER DAY OF A RIVER PEBBLE MINE.

Occupation.	Number of men.	Daily rate of pay.	Amount.
Superintendents	2	$3.75	$7.50
Captain of tug	1	1.50	1.50
Engineer of tug	1	1.50	1.50
Fireman of tug	1	1.25	1.25
Engineers of dredge	2	1.50	3.00
Firemen of dredge	2	1.25	2.50
Pumpers of dredge	4	1.00	4.00
Lightermen	2	1.00	2.00
Engineer, dry house	1	1.50	1.50
Fireman, dry house	1	1.25	1.25
Laborers, dry house	3	1.00	3.00
Extra laborers	5	1.00	5.00
Total labor	25		34.00
Ten cords of wood at $2 per cord			20.00
Oil, waste, packing, etc			2.00
Total running expenses for one day			56.00

A geological wonder.—Four miles south of Dade City in Pasco county, and near the southern limit of the hard rock belt, is Tate's shaft, in itself a curiosity and a study, and which, from its peculiar and surprising combination of formations, constitutes a geological wonder. It was a prospecting pit started in a fit of desperation by Mr. H. C. Tate. The surface indications and depth of overburden were discouraging, but the shaft was laid off 12 feet square, a country windlass of pine poles was improvised, and, with a number of hired hands, a start was made with the determination of finding what was there. After passing through an overburden of soil and sand with an average depth of 6 feet, a stratum of soft phosphate 2 feet thick and averaging about 40 per cent. of phosphate of lime was reached. Directly beneath this a stratum of 2 feet of mottled clay, more or less phosphatic, was found. Following the mottled clay came a stratum of 5 feet of land pebble phosphate, such as is found in the land pebble belt 25 to 30 miles farther south. Below this was a thin stratum of manganese clay; then a 2-foot stratum of hard rock phosphate, made up of fragmentary stuff and small boulders and specimens identical with those from the plate rock region. At the bottom of the shaft, and with an average thickness of 7½ feet, was a stratum of hard rock boulders possessing the laminations, the weight, the hardness, the high grade, and all the distinctive characteristics of the best hard rock phosphate. One boulder, the size of a bacon cask, was still in place when the shaft was visited. In itself this shaft shows substantially all the distinctive types of the phosphate belt—hard rock, plate rock, soft phosphate, and land pebble—and confounds many of the theories advanced as to the origin of the several varieties. It will be a most interesting study for scientists and geologists who may give the subject any attention. A diagram of the shaft is given.

GENERAL OBSERVATIONS.

When we consider the lack of knowledge and practical experience of the men who engaged in the mining industry at its inception, dealing as they were with a new material, singular and bulky in its character and found under strange and unfamiliar conditions, the progress, improvements, and achievements of the Florida miners in all classes of phosphate mining have been phenomenal.

From a total shipment of less than 1,000 tons in 1888, in 1892 they shipped 354,327 tons. This result could be accomplished only through perseverance, energy, and the application of a high order of intelligence; this, too, in the face of formidable competitors in the South Carolina miners, who were not only intrenched in the favorable opinion of the markets of the world, but had the advantage of many years' experience, a more thorough knowledge of their business, and of well equipped and richly endowed plants more perfectly adapted to their purposes. The marked improvement in the manner of mining, and the care bestowed upon improved machinery, looking to a higher grade of product, are worthy of praise. The sharp competition between the Florida and the South Carolina miners, and the depression of prices, but served to stimulate a closer study of the economies and caused a demand for a more improved class of machinery. The effect of this is shown not only in a less extravagant and better system of mining, but in a decided improvement in the purity, grade, and condition of the product; nor has the limit yet been reached. Land pebble will probably be raised several points in percentage, and it is possible that the product of the hard rock and contiguous belts may yet reach a much higher standard.

A cargo from the hard rock belt showed by analysis as much as 83.82 per cent. of phosphate of lime, and an analysis of several pounds, picked up indiscriminately from five pits, consisting partly of boulders and partly of fragmentary stuff, showed as much as 86.73 per cent. phos-

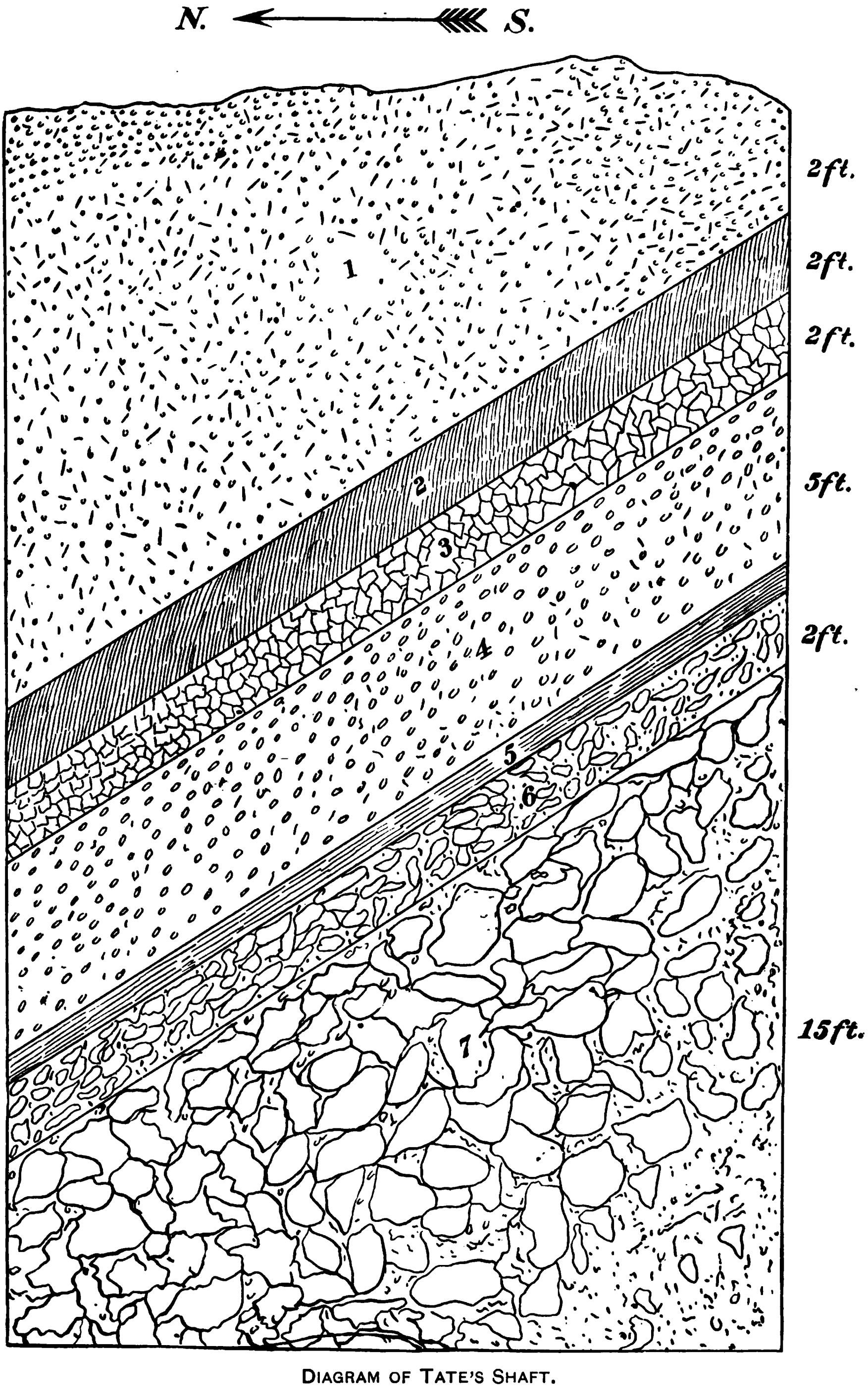


DIAGRAM OF TATE'S SHAFT.

1. Overburden, soil and sand.
2. Soft phosphate.
3. Mottled clay.
4. Land pebble.
5. Manganese clay.
6. Fragmentary and plate rock.
7. Hard rock boulder phosphate.

phate of lime. With the improved process of crushing, washing, and drying there is promise of still better results.

The absence of state or national reports, or anything more than the most general information concerning the phosphate deposits of Florida, and the wide demand for a detailed account of the several fields, their distinctive peculiarities, yield, manner of mining, and commercial value, with such facts as show their relation to our commercial, agricultural, and industrial interests, are the warrants for this fuller description and an essential to a more intelligent understanding of the importance of the subject and their inestimable value as one of our great natural resources.

The following is an extract from the law granting the right to mine phosphate in the beds of navigable waters of the state, upon certain conditions:

> SEC. 2. * * * That there shall be paid to the state of Florida the sum of fifty cents per ton for every ton of phosphate rock or phosphate deposit analyzing fifty per cent. and less, and not exceeding fifty-five per cent. bone phosphate of lime, so mined, dug and removed; seventy-five cents per ton for every ton of phosphate rock or phosphate deposit analyzing over fifty-five per cent., and not exceeding sixty per cent. bone phosphate of lime, so mined, dug or removed; one dollar per ton on every ton of phosphate rock or phosphate deposit analyzing in excess of sixty per cent. bone phosphate of lime, so mined, dug and removed, an account of which shall be rendered quarterly to the board of phosphate commissioners, and payment shall be made quarterly to the treasurer of the state of Florida for all phosphate rock and phosphatic deposit so mined, dug and removed during the quarter; *Provided*, That no person or persons shall be permitted to dig, mine or remove any phosphate rock or phosphatic deposit from the bed of any navigable waters of the state of Florida until he or they shall have first entered into a contract with the board of phosphate commissioners, in conformity with the provisions of this act, and shall file with such board a bond with good and sufficient sureties, either personal or by a guaranty company, to be approved by the board, in such sum as the board shall deem proper, conditioned to comply with the terms of such contract and the provisions of this act.

A table comparing the several kinds of Florida phosphate, prepared by Dr. Wyatt, and taken from his work entitled The Phosphates of America, may prove of interest and is here reproduced:

COMPARISON OF THE SEVERAL KINDS OF FLORIDA PHOSPHATE.

[No. 1. Boulders of hard rock phosphate, or cleaned high grade material. No. 2. Boulders and débris, or unselected material, merely freed from dirt. No. 3. Soft white phosphate, in which no boulders are found. No. 4. Pebble phosphate from Peace river as sent to market. No. 5. Pebble phosphate from Polk county drift beds, washed and screened.]

Number.	Description.	Phosphate of lime.	Oxides of iron and alumina.	Silica and silicates.	Carbonic acid.
1	Boulders (carefully selected, 120 samples).....	80.49	2.25	4.20	2.10
2	Boulders and débris (237 samples)	74.90	4.19	9.25	1.90
3	Soft white phosphate (148 samples)	65.15	9.20	5.47	4.27
4	Pebble from Peace river (84 samples)	61.75	2.90	14.20	3.60
5	Pebble from drift beds, Polk county (92 samples).	67.25	3.00	10.40	1.70

The method of selling phosphate in foreign markets, particularly in Great Britain, is as follows: It is sold at so much per analyzed unit of phosphate of lime, upon a guaranteed basis; in the case of Florida hard rock, usually 75 per cent. of phosphate of lime. Thus at 9 pence per unit (in round numbers as it is generally estimated) the price received would be $13.69 American money per ton of 2,240 pounds. In case of a higher analysis, the seller is paid for such excess at the same rate per unit. Should the analysis fall short of the guaranteed basis, then it is subject to arbitration, should exception be taken thereto.

In all contracts it is understood that the iron and alumina shall not exceed 3 per cent., but in case of excess it is subject to settlement as follows: For an excess of 1 per cent. or a fraction thereof, 2 units are deducted from the analyzed percentage of phosphate of lime; for an excess of 2 per cent. or a fraction thereof, 3 units, additional, are deducted from the percentage of phosphate of lime; for example, for 1 per cent. excess iron and alumina, deduct 2 units, and for 2 per cent. excess iron and alumina, deduct 3 units additional. In consequence of the 2 per cent. excess of iron and alumina the total deduction from percentage of phosphate of lime would be 5 units, and a cargo averaging 79 per cent. of phosphate of lime would be reduced to 74 per cent., involving a loss of 91 cents per ton.

The following table shows the selling price, per ton of 2,240 pounds, of the several kinds of Florida phosphate, delivered in London, under the English unit and percentage roll of buying, on the basis of 9½ pence for 75 per cent. goods:

SELLING PRICE IN LONDON OF VARIOUS KINDS OF FLORIDA PHOSPHATE.

Description.	Average analyzed per cent. of phosphate of lime by the cargo.	Price per unit.	Price per ton of 2,240 pounds.
Hard rock	79	$0.19265	$15.22
Plate rock	75	.19265	14.45
Land pebble	67	.19265	12.91
River pebble	62	.19265	11.94

The capital invested in the extension of railroads, the building of spurs, side tracks, etc., for the accommodation of the phosphate industry of Florida, to December 31, 1892, amounted to $635,950. In addition to this amount, over $200,000 has been expended in other improvements designed to facilitate transportation. This does not include certain improvements now under process of construction at Port Tampa, at an estimated cost of not less than $1,000,000. A detailed list of the companies which have expended the amount of $635,950 for railroads, etc., follows:

CAPITAL INVESTED IN FLORIDA RAILROADS, SPURS, AND SIDE TRACKS.

Companies.	Miles constructed.	Cost.
Florida Central and Peninsular R. R.	47¾	$238,950
South Florida R. R	27¼	136,250
Savannah, Florida, and Western R. R.	1½	7,500
Florida Southern R. R.	11½	44,000
Silver Springs, Ocala, and Gulf R. R.	35½	122,500
Florida Phosphate Co. (limited)	7	24,500
Sterling Phosphate Co.	8	28,000
Standard Phosphate and Chemical Co	2	6,000
Ceres Phosphate Co.	1½	3,750
Terraceia Phosphate Co	3	10,500
E. B. Bailey's phosphate mine	3½	10,500
Lake Hancock Phosphate Co.	1	3,500
Total	149½	635,950

CHAPTER II.

THE PHOSPHATE INDUSTRY OF SOUTH CAROLINA.

CHAPTER II.

THE PHOSPHATE INDUSTRY OF SOUTH CAROLINA.

CHAPTER II.

THE PHOSPHATE INDUSTRY OF SOUTH CAROLINA.

Prof. Francis S. Holmes, A. M., a native of the state of South Carolina, and for almost his whole lifetime a diligent and enthusiastic student of its geology and paleontology, in 1870 published his valuable work, The Phosphate Rocks of South Carolina. His name is so intimately associated with this discovery, and especially with that of its economic value, that we cannot do better than quote from his book:

GEOLOGY OF THE PHOSPHATE FIELDS OF SOUTH CAROLINA.

Names given to the phosphate rocks.—Writers have called these rocks by different names; this has occurred even in the writings of scientific men, who should have at once fixed upon one name and brought it into general use.

They have been called marl rocks, marl stone, bone phosphates, phosphate rocks, coprolites, conglomerates, and sometimes bone rocks. These names have been so used by writers of late that one is sometimes at a loss to know which of all the mineral products of the region is meant.

That there may hereafter be no mistake as to the name, we have adopted that of phosphate rocks as the best and most comprehensive. For, though by the terms bone phosphates, marl rocks, or marl stones they might very properly be called, we think the name phosphate rocks is more in accordance with popular usage, and conveys also a better idea of their true character.

And here it may be remarked that these rocks are not conglomerates, coprolites, or bones, and that the teeth and bones which are found mingled with the phosphate rocks in their beds should not be called phosphate rocks, but fossil teeth and fossil bones; and that, too, notwithstanding their richness (when thus associated) in phosphate of lime. When we speak of marl we mean simply "that compound of earthy mixtures of which carbonate of lime in any form constitutes either the sole or the chief value as a manure, and which is in such large proportion as to be of important value, and the mass soft enough to be excavated and broken down by ordinary digging utensils."

Green sand often contains no carbonate of lime, is not generally rich in calcareous matter, and therefore should be called green sand marl. Marl stone is calcareous, of a stony hardness, and not capable of being dug, because not of an earthy texture; can not be pulverized enough by ordinary implements to be used as a manure, but requires for such purpose to be burnt to lime. It is truly a limestone, and should be so called.

Clay is a soapy, non-calcareous, earthy material, but there are some forms or varieties that are improperly though popularly termed marl.

Coprolites are the undigested fecal remains of animals fossilized; of stony hardness; often petrified, and sometimes, though not often, phosphatic when taken from Tertiary or Modern rocks.

Conglomerates are strictly commingled fragments of many kinds of rocks, or they may be termed loose materials of a rocky character cemented together in masses. The conglomerates of the Ashley beds are made up of phosphate rocks, marls, pebbles, gravel, etc., cemented together by oxide of iron or lime. They often contain pebbles of water-worn quartz.

The bones which are found in such numbers intermingled with the phosphate rocks are not rocks in any sense of the term, nor are the phosphate rocks bones. Many believe the phosphate rocks to be masses of true bone fossilized, but this is a mistake; they never were bones at any time, but were originally calcareous rocks. This is evidenced by the shells, corals, and corallines of which they are composed, and by the general character of the mother bed from which they were taken to be redeposited in basins, where, by a chemical process (hereafter described) they were converted from a carbonate of lime rock or marl into a phosphate of lime rock, containing very little carbonate of lime.

* * * * * * *

Age of the phosphate basins of the Ashley.—Next in the geological series are the beds of this exceedingly interesting age; the period in which (as indicated by the fossils collected) man first made his appearance on this continent. To our mind the Post-pliocene is the connecting link between the Ante-historic or Tertiary, and the Historic or Recent age; and may be properly designated the age of Prehistoric man.

Formerly, and before these beds had been carefully studied, they were supposed to belong to the Tertiary, and therefore considered (and in the tables of classification, placed) uppermost in the division according to Lyell's arrangement, being the youngest. But since the discovery of human bones and works of art in 1844, in beds of this age, in the Ashley basin, and of similar discoveries (1854) in the lake dwellings of Switzerland, and also in the Somme valley in France, they must now be referred to a more recent date, the Quaternary period. Its sands, rocks, and fossils are replete with interest to the practical man when he sees and comprehends their meaning, and they fascinate beyond description the scientific observer, who, after long years of study, realizes in the rocks and fossils of this period the charming revelations of geology, and at once comprehends their "sweet influences."

* * * * * * *

The shells from these beds appear, when taken from the sands, as fresh and perfect as those picked up on the sea beaches of our coast, and nearly all of them are of the same species.

Recent or Historic age.—To complete the geological series, we find that after the Post-pliocene beds comes the Recent or Historic period, in which were and are now being deposited the mould of the forests and the washings of the hills, forming the soil of our cultivated fields, the mud banks of our bays and harbors, and periodically spreading over our rice fields its rich and fertilizing sediment, brought down suspended in the waters of the rivers.

* * * * * * *

Origin of the phosphate rocks.—If the reader has followed us in the attempt to make plain the order of superposition and the prominent characteristics of the geological formations as described in the foregoing pages, he is now prepared to go with us, also, into a consideration and examination of the origin of these rocks and their remarkable position, as seen in the Charleston basin.

And first, we should always bear in mind this important fact, that though these basins were formed in the Post-pliocene age, the rocks deposited in them do not actually belong to that age, but in fact to the Eocene, an older formation. It has been ascertained beyond doubt, that frequently rocks or fragments of rocks of older formations, and therefore of greater age, are found in newer deposits of a comparatively recent date. Quartz pebbles and fragments of water-worn crystalline rocks are often seen embedded in modern clays and sands. The phosphate rocks of these basins, like the quartz pebbles just named, have been derived from an older formation; viz., the Eocene marl, or the great Carolinian bed of marl, which is the foundation of the whole seaboard country of South Carolina, and is composed of the Santee, Cooper, and Ashley river marls, which in the aggregate are 700 feet thick, and extend from North Carolina into Georgia. Before the low country of South Carolina was raised above the level of the ocean, the waves of the Atlantic beat upon the granitic hills of Edgefield, Lexington, and Richland. The shallow water of the coast, with its submarine formation of undulating sand banks, was then, as now, resting upon this surface of the great marl formation of the Eocene age; both were below the level of the ocean, exposed to the degrading influence of its waves, and bored by mollusca and other marine animals.

The Eocene marl is here represented as we have found it, with its surface washed into deep cavities and holes, bored by the animals just named and honeycombed to the depth of 5 or 6 feet. This is its condition off Charleston harbor at the present time; and wherever the surface of the bed inland has been uncovered, it is found irregular and broken, and the phosphate rocks show this plainly. From the coarsely honeycombed surface of this mother bed, fragments were being continually broken off by the waves, rolled over the sand beds, which wore off their angular edges, and finally deposited them in extensive masses in the great hollows or basins below the ocean level.

We apprehend it did not require a very long time, nor much friction, to reduce these comparatively soft lumps of marl rock to the rounded or nodular forms they now have. Every gale drove them further and further upon the submarine beach, until at last they were deposited in the lagoons or basins formed within the sand reach of the coast.

Prof. Ansted, describing the phosphate beds near Cambridge, England, writes—and we quote him in corroboration of our own views on this subject: "Many years ago a discovery of phosphate of lime was made in the so-called crag beds of Suffolk, and afterwards in the green sands of many parts of the southeast of England." (This corresponds to the Eocene or green sand of South Carolina.) "The former contain beds consisting of nodules of exceeding hard material, which, when ground, are soluble in sulphuric acid, and then form a most valuable manure. The proportion of phosphate of lime in these nodules varies from 50 to 60 per cent." Now observe the analogy between the English and Carolina beds as regards origin. Prof. Ansted continues, "The crag nodules are found in the newer Tertiary gravels, but the nodules themselves are believed to have been washed out of older rock, also of Tertiary age." It was undoubtedly so with the South Carolina phosphate rocks.

The next great change was the upheaval of the whole seaboard country by some geological agency, and the elevation of the coast above the level of the ocean. When the sand hills and the submarine lagoons were raised, the basins contained sea or salt water, and must have been so many small salt lakes along the seacoast, having their bottoms covered or paved with a thin layer of the nodular fragments of marl rock. As the evaporation of the salt water progressed, what was left became day after day a stronger brine, until, at last, a deposit of salt ultimately formed as a crust upon the pavement of marl rocks. And here we must remind the reader, that these nodular fragments of Eocene rocks are composed (like the mother rock from which they had been broken off) entirely of the dead shells of marine animals which, age after age, were deposited at the bottom of the ocean or Eocene sea, and finally became an immense bed or formation of marl, inclosing throughout its great depth not only the polythalamous shells, corals, and corallines, but the teeth and bones of sharks and other fish, and of whale-like and alligator-like animals, such as alone live in the sea; but no remains of any land animal have ever yet been found in it. We say it without any fear of contradiction, and challenge proof of a single specimen being obtained from, or embedded in the nodules (phosphate rocks), or from the marl bed itself the mother rock. All the remains of land animals obtained in such vast numbers are mingled with, and not embedded in, the nodules found in the phosphate basins; and this mingling of bones and teeth occurred in the Post-pliocene age after the elevation of the basins above the ocean level. It was in this Post-pliocene age, the period when the American elephant or mammoth, the mastodon, rhinoceros, megatherium, hadrosaurus, and other gigantic quadrupeds roamed the Carolina forests, and repaired periodically to these salt lakes or lagoons, or, as they are called in Kentucky, "salt-licks;" and during a series of indefinite ages, engaged, as they were, first sipping brine, then licking salt, and depositing their fecal remains, and ultimately their bones and teeth, in fact their dead bodies, in these great open "crawls" or pens, thus preparing, as ordained beforehand by the Great Master Builder of our earth, a storehouse of rich material for man's use. They converted the rocks, prepared of old at the bottom of the ocean, into the basis of a most wonderful fertilizing substance.

* * * * * * *

What are fossils and petrifactions?—The important agents being not only water holding carbonic acid in solution, whereby the lime was dissolved particle by particle, but the fecal matter from the animals named, would furnish the phosphoric acid to supply the portion of the lime dissolved out of the mass, and thus convert these nodules into a phosphate rock.

Additional evidence may be afforded by the fact that the bones of land animals, as found intermingled with the nodules or phosphate rocks, when recently taken from the living animal, contain about 51 or 52 per cent. of phosphate of lime, but when associated, as they must have been for centuries, with the materials of the phosphate rock basins, they necessarily imbibed an additional amount of this essence, and now yield upon analysis 92 per cent. of phosphate of lime. And where did this additional amount of phosphate of lime come from? It follows, therefore, that if these bones had contributed to furnish the phosphoric acid of the rocks (as some suppose) they would have been deprived of all they possessed; and, therefore, it seems very plain, that from the fecal matter (dung and urine) deposited by land quadrupeds during a series of ages, dissolved by rain, and its juices carried down to be imbibed by the marl nodules, atom after atom as the carbonate of lime was dissolved out of the rock, has been derived the chemical agent which converted the Eocene marl nodules into phosphate rocks. To the bones which are buried with them was imparted also the additional amount of phosphoric acid they are now found to contain in excess of what they possessed when in a recent or living state, and not, as has been suggested, from the excrement of birds.

* * * * * * *

The fish-bed of the Ashley.—The idea prevails that the fish-bed of the Ashley basin, alluded to in Prof. Tuomey's geological report, is the phosphate rock stratum with its associated teeth and bones. This is an error into which many have been led. In Prof. Tuomey's report, p. 165, he writes: "The most remarkable feature in the fauna of the period of the deposition of these beds was the vast number of cartilaginous fishes. It would seem as if about the close of the Eocene period these voracious monsters, conscious of their approaching end, had congregated here to die, and it is no exaggeration to say that more than a bushel of fishes' teeth have been collected at Ashley ferry within the last few years. I have visited the locality several times and never without finding a large number of specimens. As the marl is washed away by the river and tides, the fossils are left exposed at low water, and in this way the locality appears almost inexhaustible and well deserves the name of the fish-bed of the Charleston basin."

The surface or upper marl beds are here alluded to, that is to say, the Ashley marl and sands, and not the overlying phosphate rock bed.

The fish-bed of the Ashley had been thus named by us before Mr. Tuomey had visited South Carolina. In the above he only expresses his approval of the name given it.

At that time Prof. Agassiz had not been on the Ashley.

* * * * * * *

DISCOVERY OF PHOSPHATE IN SOUTH CAROLINA.

Sometime in November, 1837, in an old rice field about a mile from the west bank of the Ashley, in Saint Andrew's parish, we found a number of rolled or water-worn nodules, of a rocky material, filled with the impressions or casts of marine shells. These nodules or rocks were scattered over the surface of the land, and in some places had been gathered into heaps, so that they could not materially interfere with the cultivation of the field.

At that time we were students of geology and paleontology, and the interesting and beautifully preserved forms of shells, teeth, and bones mingled with the rocks filled with the casts of shells, corals, and corallines, attracted our attention, and in a very short time enriched our cabinet with thousands of remarkable specimens. These, during a term of six years, we studied carefully and labelled as best we could. The appointment of Mr. Ruffin, in 1842, to make a survey (geological and agricultural) of the state, as ordered by the legislature, was generally understood to be mainly for the purpose of introducing the use of marl and lime as fertilizers; marl having been successfully and extensively used by the farmers of Virginia, and the results obtained having been found to surpass their most favorable anticipations.

Mr. Ruffin immediately called the attention of the planters to the importance of searching diligently everywhere for marl beds and other sources from which calcareous earths or lime could be obtained.

Shortly after his arrival among us, we had the satisfaction of pointing out the exposures of marl on the Ashley, and of submitting for his examination specimens of the nodular rocks scattered over the fields just alluded to. As these rocks contained little carbonate of lime (the material, of all others, then most eagerly sought for) the nodules were thrown aside and considered useless as a fertilizing substance.

Mr. Ruffin also intimated that as the great Carolinian marl bed was extensively exposed on the river banks near by, was easy of access, and readily dug with ordinary implements, he thought it well worth transporting in carts and wagons, 4 or 5 miles; especially as it was so much richer in carbonate of lime than the marls of Virginia, which were often carried to a greater distance; the former having from 50 to 80 per cent., the latter averaging only about 40 per cent. At that time marl, and everything resembling marl, was carefully scrutinized and analyzed by Professors Shepard, J. Lawrence Smith, and Wm. Hume, and some of the results published.

From a prize report, made to the State Agricultural Society of South Carolina, November, 1844, of successful experiments in marling cotton and corn lands, and for which their premium was awarded, we extract the following, which forms a part of the history of phosphate rocks:

"In a low part of an old field (December 9, 1843) we attempted to bore with an auger below the surface to ascertain the nature of the earth beneath, and with the hope of finding marl. We did not penetrate 2 feet before the auger was thrown aside and the spade and pick resorted to. On removing the soil above the rocks, they were seen in a regular stratum about 1 foot thick embedded in clay, and seemed to be identically the same as those found scattered on the surface of an adjoining field; all of them bearing the impression of shells, and having similar cavities and holes filled with clay. Continuing our excavation, the yellow marl was reached about 5 feet from the surface. As the water sprung rapidly we had to abandon the work, but with the satisfaction of knowing that the marl underlaid the stratum of rock and was to be had on our own farm, and in the midst of our cultivated fields, thereby enabling us to save carting 1 mile from the river bank.

On the 22d of February following (1844) another attempt was made to find the marl, and it was discovered near an old causeway on the edge of the high land under the marsh. The following is a tabular arrangement of the strata taken from above the marl which lies 4 feet 6 inches below the surface of the mud:

Strata.	Feet.	Inches.
1. Marsh mud filled with roots	1	0
2. White sand and a few pebbles	0	3
3. Marl rocks (phosphate rocks)	1	3
4. Dark sand, lumps of blue clay, and pebbles	1	0
5. Blue and gray sand, with a quantity of finely divided shelly matter (Post-pliocene shells), with casts in soft marl and fish bones and teeth.	1	0
Total	4	6
6. Yellowish marl containing 61 per cent. of carbonate of lime	2	0

At this depth the color changes with a green tint, and the marl increases in strength to 71 per cent. of carbonate of lime, and continues thus 7 feet deeper. The surface of the marl bed was found to be very much broken and irregular, having deep holes in it filled with blue mud and sand. Arrangements were immediately made to dig and marl lands extensively for the next crop, and a pit was opened 20 feet wide and 40 feet long."

It was on the 23d or 24th day of February, 1844, whilst engaged in the removal of the upper beds covering the marl, and preparing for opening the large pit just alluded to, the laborers discovered among the rocks several stone arrow heads and one stone hatchet; they were found directly under the roots of a large oak, which was cut down and its roots removed to make way for our marling operations. The tree stood just within the margin of the high land skirting the marsh; the pit, as laid out, encroached upon the high land side about 10 feet, and the depth of the soil was about 3 feet above the rocky stratum.

The late Dr. Thomas L. Burden, an accomplished gentleman and scholar, and a true lover of nature, more especially of the departments of botany and paleontology, accompanied us almost daily, collecting fossils in the neighborhood. We had during our explorations discovered, upon one or two occasions, a few arrow heads and spear heads (for such we took them to be), in out of the way places, and differing so greatly in their general characteristics from those commonly found scattered all over this continent, that we examined and studied them again and again with deep interest, and were continually comparing them with the well known similar forms obtained from the Indian mounds of America, and attributed to the handiwork of the aborigines. But when found under the oak at the marl pit, among the marl rocks, as they were then termed (and very properly too, for they are indeed marl rocks derived from the mother bed of Eocene marl), every precaution was immediately taken to satisfy ourselves fully as to the possibility of their being of the same age as the mound arrow heads and hatchets, but washed into a gully in after ages, and now found mixed with the marl rocks (phosphate rocks), and therefore accidental occupants of the place.

After a careful study of everything connected with their discovery, the place and stratum in which they were found, and their remarkable forms, we were satisfied that they belonged to and were deposited in the same geological age to which the bones and teeth of the mastodon, elephant, rhinoceros, horse, and other land animals belong, and which are found associated with them in the same matrix or mother bed of clay, which is of the Post-pliocene period, and which we have since designated as the Prehistoric age of man.

Alas, for young students and their beautiful theories! Prof. Tuomey about this time visited the locality, examined the specimens and everything connected with their discovery and exhumation, together with all the surrounding strata, and advised against their publication, as it was possible for them to have fallen into a hole at the foot of the tree, or the burrows of some animal; and, should no more of such relics hereafter be found, our reputation as observers in the geological field would be affected. It was good advice and we took it, though we certainly were convinced against our will.

* * * * * * *

Not long after finding the above named relics of human workmanship, and while engaged in our usual visits to the Ashley bed, a bone was found projecting from the bluff immediately in contact with the surface of the stony stratum (the phosphate rocks); we pulled it out, and behold, a human bone! Without hesitation it was condemned as an accidental occupant of quarters to which it had no right, geologically, and so we threw it into the river. Alas! we have lived to regret our temerity and rashness. A year after a lower jaw bone with teeth was taken from the same bed, and we now have it in the cabinet. Subsequent events and discoveries show, conclusively, that the first discovered human bone was "in place," and that the beds of the Post-pliocene, not only on the Ashley, but in France, Switzerland, and other European countries, contain human bones associated with the remains of animals and relics of human workmanship, proving most conclusively that the Carolina specimens were found "in place," and as the European discoveries were made in 1854 and ours in 1844, to South Carolina should be awarded the honor of the first discovery, and the determination of the Paleontological age of the Post-pliocene beds. It stamps it as the Prehistoric age of man, the connecting link between the Tertiary and the Recent age, the true Quaternary period in its geological history.

Whilst engaged in manufacturing saltpetre at Ashley ferry, on the west bank of the river, during the late Confederate war, the lime or calcareous earth, necessary in such operations, was obtained by sinking pits into the Eocene marl bed.

Upon the removal of 4 or 5 feet of the upper layers, the workmen discovered in one part of a pit a number of oddly shaped nodules, resembling somewhat the marl stones (phosphate rocks) found in the stratum above the marl, but more cylindrical in form and not perforated, and having their exterior polished as though each individual specimen had received a coat of varnish; they appeared to have been deposited in a large cavern or pocket in the marl bed. The quantity taken from this pocket was estimated at several wagon loads.

We supposed them to be coprolites, or the fossilized excrements of some of those large aquatic mammalia of that age, whose bones are found in great numbers in the marl, and also mixed with the phosphate rocks in the basins. The zeuglodons, squalodons, and phocodons swarmed in the waters of that period, and they had as associates huge crocodiles or alligator-like creatures which roamed the submarine forests like an army of locusts seeking their prey.

The amount of phosphate of lime found by Dr. Pratt, in his analysis of these supposed coprolites, is small compared with that of the phosphate rocks, being only 15 per cent. But it is not surprising, as the marl must have extracted a large portion of their phosphoric essence.

This completes the history of the marls and the phosphate rocks up to the close of the Confederate war in 1865, and which for 4 years excluded all Europe, their doings and their publications, from Confederate eyes; and it was not until 1867, when we had recovered sufficiently from the war to import a few books from England, was ascertained what had been done during the interval by scientific men of that country.

Early in the month of August, 1867, the ninth or tenth day, our friend Dr. N. A. Pratt, with whom we had been intimately associated during the war, brought us a small fragment of rock and enquired if we knew it. We replied, "Yes; as well as we knew our children; we have been familiar with it since 1839, have a large collection of specimens at the College of Charleston, and would be glad to submit them to him for examination." To this the doctor readily assented, and we repaired immediately to the college. On examination (there were 50 or 60 specimens in the closet) he said, "I think that you are mistaken, these are not the same kind of rock as that in my hand." We rejoined, "There is no doubt in our mind about it, but feel confident they are the same." We suggested that a quantity should be ground up finely, so as to obtain a fair sample for analysis. Dr. Pratt, accordingly, took several pounds, enquiring at the same time as to its chemical composition. We replied, "Prof. Tuomey made a crude analysis of it some years ago. His notes of the result were burnt with our library; but we well remember that the amount of phosphate of lime, 16 per cent., was considered too small, and the carbonate of lime, iron, and sand, too great to admit of its being used advantageously for agricultural purposes."

At that time patent fertilizers and fashionable superphosphates were unknown; in fact, guanos in this country had been used but a short time, hence the anxiety of scientific men to develop the great masses of marl which were found on the banks of the rivers in South Carolina.

We well remember relating, too, an incident which occurred some years ago regarding these rocks. A gentleman of Saint Andrew's had a large quantity of the rock pounded at a considerable expense, intending to use it as a fertilizer, but Mr. Ruffin, and the party who accompanied him on the visit, dissuaded the old gentleman from using it by saying it would produce no beneficial effect. This was in the year 1843.

After selecting the specimens intended for analysis, the doctor remarked that the small specimen which he possessed was obtained from the neighborhood of Charleston, but did not name the locality, nor from whom he had received it, nor did we ask him. He also remarked that it contained a much larger quantity of phosphate of lime than is known from published accounts of the Ashley rocks, by Shepard or Tuomey, and that it was valuable as a fertilizer if all the Ashley rocks were of the same quality, though if found in quantity, as we had represented, he was fearful the average percentage of phosphate of lime would not be so great, as our specimens indicated a greater amount of silex, iron, and lime than was found in that in his possession.

The day after this interview, Dr. Pratt informed me that the analysis, though not completed, indicated to his surprise even greater results than he had obtained from his specimen, and that it was reduced to a certainty that the Ashley ferry rocks were undoubtedly much richer in phosphate of lime. When the analysis was completed, it was ascertained to contain nearly 60 per cent. of phosphate of lime. Dr. Pratt said, "The question with me now is, the extent of the formation, and this must be looked into at once." Again we rejoined, "This is well known, and though we can not take you up to the Ashley today, because of engagements at the college, we will send Mr. Jonathan Lucas with you tomorrow, and you can then see and judge for yourself; for he knows the stratum and its outcrop, having been with us during the war whilst engaged manufacturing saltpetre." At the same time we also told the doctor that the extent of this deposit was marked upon a map which was still in our possession, and it should be looked for. The map was afterwards found and submitted to him for examination.

The necessary arrangements being made, Dr. Pratt left the next day with Mr. Lucas for Ashley ferry, saw the rock *in situ*, and admitted, it surpassed his anticipation. On the very day the doctor and Mr. Lucas were visiting the Ashley, we received Ansted's book from London, on the Geology of the Cambridge Beds of Phosphates, giving in detail the analysis of a rock similar to that of the Ashley, and discovered sometime during our Confederate war. His description of the

Cambridge rock corresponds in almost every particular with that of the Ashley beds, and in a most remarkable manner corroborated our statement made years ago; viz., that Charleston was located, geologically, on the same formation as that of the great city of London.

On the doctor's return from the Ashley with Mr. Lucas, we had the pleasure of placing the book in his hands, and directing his attention to the article. Several persons were present at the time, and all expressed their surprise.

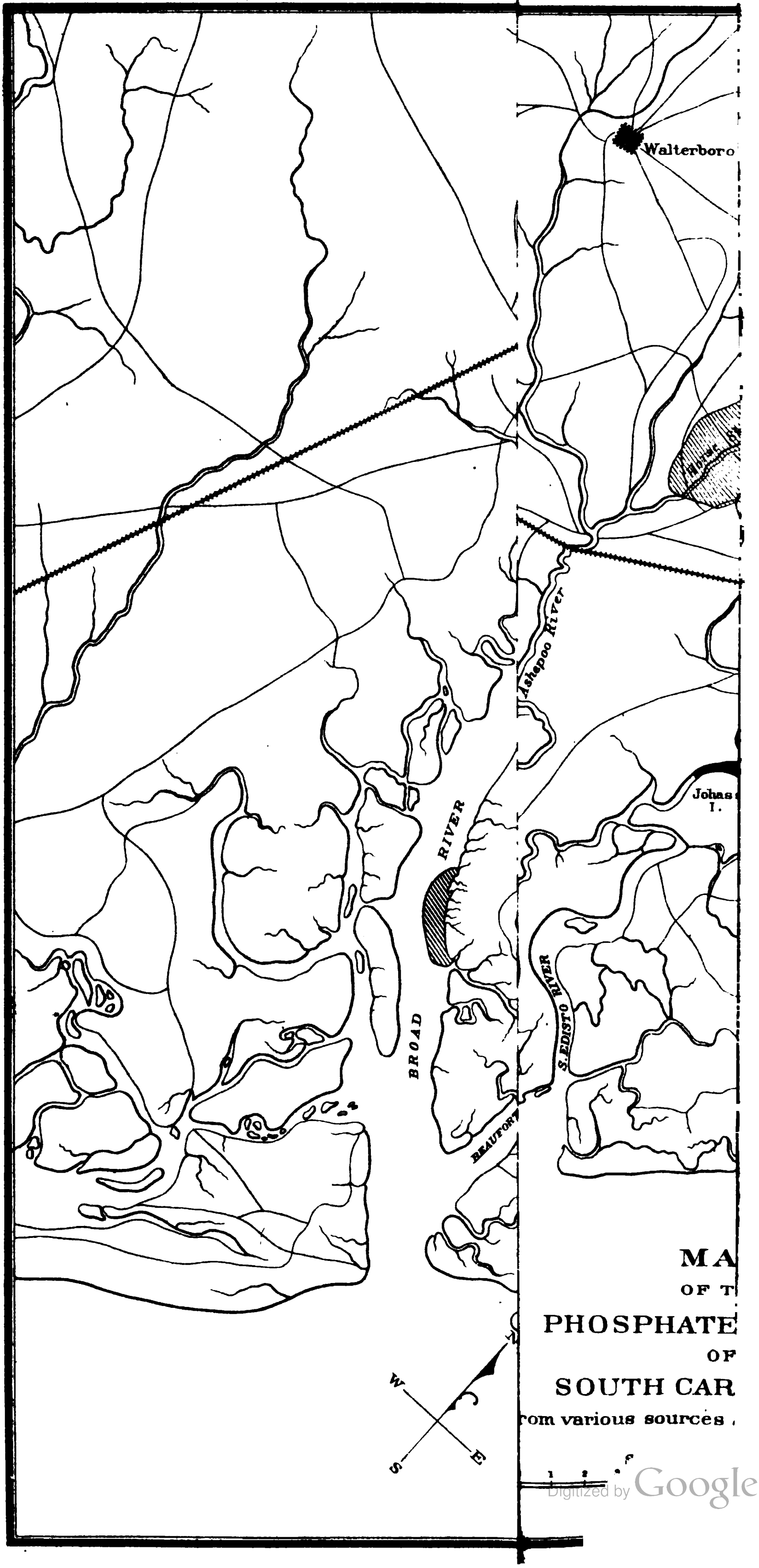
The thickness of the beds described, the formation of strata, and the percentage of phosphate of lime were almost exactly those of the Ashley beds; and it was remarked, that if the war had not occurred, which cut us off from all English publications, the value of the Ashley beds would have been known to the Carolinians in 1864. The Hon. C. G. Memminger was the first person to whom we applied for aid to develop this additional source of wealth. At first he did not seem to appreciate its value, but when we exhibited our own publications, extending through many years, and also the work of Prof. Ansted of England, which had been received only the day before, he said, on taking leave of us, "That book of Ansted's is of the first importance in enabling you (Dr. Pratt and the writer) to establish the worth of your discovery; be careful of it."

That book did ultimately convince many of the value of this discovery, and aided us greatly in obtaining the necessary means to develop the phosphate deposits of South Carolina.

For several months after the discovery we were engaged in making explorations and arranging future work, and had lost sight of or had forgotten to inquire concerning the specimen first analyzed by Dr. Pratt; and it was not until some time in the early part of 1868, we were informed by a friend, Dr. F. Peyre Porcher, that Dr. Ravenal had given the specimen to Dr. Pratt, and afterwards by Dr. Pratt himself when we told him of it, and that Dr. St. Julien Ravenal had been inquiring if we possessed a series of specimens of the several geological formations found in the Ashley beds. And here it may be proper to state, that it was the first time since the war that Dr. Ravenal had conversed with us about marls or geological specimens. Dr. Pratt said the specimen was given to him by Dr. Ravenal, who had analyzed it and found 15 per cent. of phosphate of lime. Prof. Tuomey, as before stated, found 16 per cent. years ago in these rocks. Dr. Pratt analyzed the specimen obtained from Dr. Ravenal and found 34 per cent., and afterwards those placed in his hands by us at the college and found nearly 60 per cent. in them.

To continue the history. After six weeks of unavailing exertions in obtaining means to develop these treasures of the Ashley river, and to convince the good people of Charleston of the value of the discovery, we were obliged to resort to Northern cities for aid. Mr. James T. Welsman of Charleston, one of the few who fully appreciated the discovery, furnished the necessary funds. George T. Lewis and Fredrick Klett, esqs., two gentlemen of Philadelphia, immediately took the matter in hand, rewarded us both for our discovery, and furnished the capital for the first phosphate mining association,—The Charleston, South Carolina, Mining and Manufacturing Company.

Eleventh Census of the United States.



KINDS OF PHOSPHATE, MACHINERY USED, ETC.

We are indebted to Maj. E. Willis of Charleston, South Carolina, an acknowledged authority on the subject, for the following description of the deposits, the several kinds of mining, the machinery used, etc. The accompanying map of the South Carolina deposits, revised by Maj. Willis down to a recent date, gives an approximate idea of their extent, and shows their relation to the important subject of transportation both by sea and rail.

Land and river rock.—There are two classes of phosphate deposits, land and river, the extent of the former being estimated at 55 square miles, and of the latter 50 square miles. Land rock is tolerably uniform in grade. Its color varies from light yellow to heavy brown. It is nearly free from iron and alumina, but contains sufficient carbonate of lime to make an acid phosphate, and from this are produced ammoniated or potash compounds, that promptly dry and remain in a pulverulent state after being treated with sulphuric acid. In the United States land rock has been mainly used, it being preferred to that from the rivers.

River rock has, since 1870, been preferred in all foreign markets to the land rock, and much the larger part of that mined still goes abroad. In color it is from gray to blue-black, with specific gravity of about 2.4 and hardness about 3.15.

At the lower left hand corner of the accompanying map will be seen the extensive beds at Beaufort and vicinity, and in the Beaufort river and its branches. Then a little to the right the Coosaw river and Chisholm's Island, one of the most prolific sources of phosphate rock in the state. Near the centre is shown the section bordering the Edisto river and the Horseshoe creek, where workable deposits are found. There appear farther to the right the deposits of the Stono, Ashley, Cooper, and Wando rivers, and those in the neighborhood of Charleston.

The colored sections do not all represent workable deposits, the lighter portions being indicative of the smaller or less profitable sections, and the darker where mining is extensive or profitable. All the inlets from the sea, in the vicinity covered by the map, contain more or less phosphate rock. It is found at depths beneath the surface varying from 1 to 20 feet.

The nodular stratum varies from a few inches to 2 feet 5 inches in thickness, but the latter is rarely observed; ordinarily it is from 10 to 15 inches, and averages about 10 inches. Where the deposit exceeds 15 inches in thickness it rarely extends beyond a limited area, and is generally due to local accumulation, or is the result of accidental superposition of a few large nodules. The yield per acre varies from 500 to 1,200 tons, the average yield of land beds now worked being 800 to 1,000 tons per acre. The yield per acre stands in a certain ratio to the thickness of the stratum, but not invariably so, as the compactness is an important factor in determining the amount of production. In many instances the stratum is underlaid by marl, occasionally to a depth of 250 feet.

Land mining.—The method of land mining phosphate rock is simple. Long trenches are laid off, from which the overlying earth is first removed; then by hand labor, with pick and shovel, the rock is taken from the trenches and thrown into piles, from which it is taken by barrows or carts to be washed and crushed. The laborers are usually negroes from the surrounding neighborhood and near towns or cities. Italians were employed several years ago by a number of companies, but they were soon replaced by negroes, who, for climatic and other reasons, are better adapted to the work.

River phosphate.—River phosphate is found in deposits on river beds, in depths varying from exposure at low tide to 10 or 15 feet below the surface of the water. It is occasionally found under layers of sand and mud. The nature of the deposit and the depth of the water determine, in a large measure, the method of excavation. Where the rock is not over 3 or 4 feet below the surface of the water mining is done by hand; in deeper water dredging is resorted to. Where the rock is taken from navigable streams it is the property of the state, and is subject to a royalty of $1 per ton.

Hand picking.—At low water, where the bed is easily accessible, workmen with pick and shovel loosen the rock and throw it on scows or flatboats within convenient reach in shoal water. When the tide rises the operations cease until the next low tide, and the loaded scows are moved to convenient points for shipment to washers and crushers, or for transfer to vessels. The localities in which this mode of mining can be carried on are few, but they have yielded large quantities of rock at moderate cost. In the deeper water, where dredging is not resorted to, much rock is obtained by divers, who with pick and crowbar loosen the material by expertness obtained only by those skilled in this particular work. A diver is enabled to bring to the surface rocks which would require the strength of three or four men to handle above water.

Dredging.—The dredging machines are used to most advantage in about 12 feet of water. They are powerful machines, especially made for the work, of several varieties of construction, and with claws and scoops capable of raising immense weights. An ordinary day's work, under favorable circumstances, lifts about 100 tons of rock. The rock having been gathered into dippers or buckets propelled by steam, is emptied on a grating or conical washer where it is cleansed of the mud and sand by means of heavy streams of water. Marl, sandstone, or oyster shells are then easily detected and thrown aside. The rock which is partially cleaned then descends or is thrown by the machinery on a crusher, and thence into a second washer, where the remaining impurities are separated. The washing apparatus consists of either upright and caldron-shaped or shaft washers, which discharge the washed rock upon lighters for transportation to the drying sheds, where it is heaped upon and around a system of perforated iron pipes. Hot air is then forced through these pipes, and, escaping through the perforations, in a few days thoroughly dries the originally saturated rock.

Machinery for loading and discharging.—The machinery for loading and discharging at the works of the Coosaw Mining Company will serve to explain these processes. At the first and second piers wet phosphate rock is hoisted by donkey engines from lighters, dumped into cars, and in them rolled to the drying bins, where it is piled up on the system of perforated iron pipes to be dried. At the third pier a vessel receives a cargo of dried rock, delivered directly into the hold by dumping cars, which are loaded in the drying sheds from large iron buckets hoisted by steam power.

Crushing and washing.—The machinery for crushing and washing the rock is expensive and elaborate. The washer in general use is known as the single-screw washer. It consists of four half-circular boxes resting in a frame on an incline of 18 inches, and 25 feet in length. These boxes are cased with iron. In each box is an octagonal shaft, also cased with iron, and having on each face teeth or blades set at such an angle to the shaft as to form a spiral screw, with a twist of 1 foot in 6 feet. Over each box or washer are strong cylindrical crushers or breakers armed with steel teeth, acting against an iron plate, and set about 4 inches from the plate. Through these breakers the nodules of rock are dumped, and by them broken to a uniform size of 4-inch cubes. The rock is then agitated by these bladed shafts, which make about 18 revolutions per minute, and are submerged in water contained in the tub or box. The rock is forced forward and up the incline against a heavy stream of water (which enters at the upper end of the washer box) and empties itself through an overflow at the end. The abrasion of one piece of rock against another, in its passage through the box, rids it completely of all foreign matter, such as mud, etc. From this overflow it falls upon screens, set one above the other, the first screen having about half-inch meshes, and the lower screen about quarter-inch meshes. From this lower screen the fine rock falls upon an oscillating screen still lower, which serves to rinse the small rock thoroughly. Over all these screens a flow of water passes continuously. From them the rock falls upon an elevated platform, and is thence taken to the sheds or storehouses. The water used is drawn directly from the river and forced up into large troughs by means of heavy pumps, both steam and centrifugal. The washers are considerably elevated for the purpose of getting rid of the débris, which is carried off by means of large troughs. The loss by abrasion and clay adhering to the rock varies from 50 to 60 per cent. The capacity of each washer is from 40 to 50 tons of clean rock in 10 hours.

ANALYSES.

Analyses made by Dr. C. W. Shepard, jr., in 1880, of several hundred samples of South Carolina rock phosphate, show the following average percentages for the various constituents:

RESULTS OF ANALYSES OF SEVERAL HUNDRED SAMPLES OF SOUTH CAROLINA ROCK PHOSPHATE.

Constituents.	Per cent.	
Phosphoric acid	25.0 to	28.0
Equivalent to bone phosphate of lime	55.0	61.0
Carbonic acid	2.5	5.0
Equivalent to carbonate of lime	5.0	11.0
Sulphuric acid	0.5	2.0
Lime	35.0	42.0
Magnesia	Traces	2.0
Alumina	Traces	2.0
Sesquioxide of iron	1.0	4.0
Fluorine	1.0	2.0
Sand and silica	4.0	12.0
Organic matter and combined water	2.0	6.0
Moisture	0.5	4.0

Another table is given below, prepared by Maj. E. Willis of Charleston, South Carolina. It shows the general composition of the South Carolina phosphates, and is based upon the analyses of several hundred shipments:

RESULTS OF ANALYSES OF SEVERAL HUNDRED SHIPMENTS OF SOUTH CAROLINA PHOSPHATE.

Constituents.	Per cent.
Phosphoric acid	26.0 to 29.0
Equivalent to bone phosphate of lime	57.0 " 63.0
Carbonic acid	2.5 5.0
Equivalent to carbonate of lime	5.0 11.0
Sulphuric acid	0.5 2.0
Lime	35.0 42.0
Magnesia	Traces 2.0
Alumina	Traces 2.0
Sesquioxide of iron	1.0 3.0
Fluorine	1.0 2.0
Sand and silica	4.0 12.0
Organic matter and combined water	2.0 6.0
Moisture	0.5 4.0

It may be of interest to know the average composition of some of the most important phosphates from countries other than the United States. Dr. Wyatt, in his Phosphates of America, gives such a table, and it is here reproduced:

AVERAGE COMPOSITION OF PHOSPHATES FROM COUNTRIES OTHER THAN THE UNITED STATES.

Constituents.	Spanish and Portuguese.	Navassa.	Aruba.	Curaçao.	German.	French Ardennes.	Mexillones guano.	Cambridge coprolites.	Norway apatites.	Russian coprolites.	Somme, France.	Belgian (average) calcined.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Moisture	1.20	5.73	5.53	.75	1.27	5.20	10.90	1.24	.47	5.10	2.00	.25
Water of combination	3.60	4.93	6.03	1.07	2.17		11.01	2.40	.36		1.02	
Phosphoric acid	32.36	31.69	32.00	39.62	29.99	23.45	33.70	26.85	42.34	27.48	35.70	20.59
Lime	47.28	38.00	43.06	50.04	42.20	40.48	28.00	42.96	51.63	43.00	51.20	52.50
Carbonic acid	3.20	2.40	5.30	7.55	4.15	4.83	3.70	7.06	5.20	4.60	4.10	5.55
Oxide of iron	1.93	4.25	3.05	traces.	5.15	2.97	*a* 8.01	4.16		3.40	1.40	18.61
Alumina	1.03	8.81	2.20	.45	.12	2.15		3.01		1.09	.70	
Sulphuric acid	traces.	1.10	traces.	traces.	traces.	1.30		.76		1.04	.76	......
Fluorine	2.87		.72	traces.	1.71	.94		1.15		.47	1.92	......
Insoluble silicious matters	6.53	3.09	2.11	.52	13.24	18.68	4.68	10.41		13.82	1.20	2.50
	100	100	100	100	100	100	100	100	100	100	100	100
Equal to tribasic phosphate of lime	70.55	69.85	69.75	86.37	65.40	51.22	73.45	58.53	92.30	59.97	78.50	45.30

a Various undetermined.

These per cents. may be compared with those of the South Carolina product, immediately preceding, and with those of the Florida product as shown in Chapter I of this report.

CHAPTER III.

GENERAL STATISTICS OF THE PHOSPHATE INDUSTRY.

CHAPTER III.

GENERAL STATISTICS OF THE PHOSPHATE INDUSTRY.

Nearly all the statistics used in this chapter have been collected by the Department of Labor from original sources. As stated in the earlier part of this report, many obstacles existed in the way of perfect statistical information. Wherever these obstacles have ultimately prevented a fairly complete and accurate statement from being made, explanations are given. At the close of this report will be found two tables of statistics relating to the cost of production of phosphate. Table I is entitled, Cost of Production of Phosphate in the United States, 1890–1892—Land Mines. The facts in this table are grouped in sub-tables as follows:

A.—Period covered and quantity of product.
B.—General description, capital invested, etc.
C.—Distance, means, and cost of transportation.
D.—General statement of cost for the period.
E.—Elements of cost in one ton of 2,240 pounds.
F.—Per cent. of each element of cost in one ton of 2,240 pounds.
G.—Additional cost of certain theoretical elements for the period.
H.—Additional cost of certain theoretical elements in one ton of 2,240 pounds.
J.—Rates of wages.

Table II is entitled, Cost of Production of Phosphate in the United States, 1890–1892—River Mines. The facts collected under this table have been grouped in like sub-tables as stated for Table I.

The period taken for this investigation has invariably been the last obtainable complete fiscal year of each mine investigated. The years have not always been contemporaneous in all the mines, because conditions were such that this feature could not be observed; but only one year's production or the facts for one year have been stated in the table. It was found impossible to fix an arbitrary date and ask the proprietors of all mines to bring their statistical information to conform to that date. Of late years it has been found that in collecting statistics of production it does not matter materially whether the exact period of time by the calendar is observed for all establishments, but that a like period as to time covered should be observed. For instance, it does not matter in securing the aggregate production in an industry, whether the year for each particular establishment closes on the 31st of March, or whether the year closes on that date for one establishment and for another establishment a month earlier or a month later, etc., the point being to cover one year's conditions only for each establishment. As a rule, however, it will be found that the facts given in the two general tables described are for the year closing nearest to December 31, 1892.

These tables comprehend for the state of Florida, 88 land mines and 18 river mines, or 106 mines for the state; 1 land mine for North Carolina; and 23 land mines and 7 river mines for the state of South Carolina, or a total for the latter of 30 mines, the whole number of mines considered being 137. In the phosphate industry production is usually measured by tons of 2,240 pounds, while sales or consumption are measured by tons of 2,000 pounds. From the general tables it is found that the total amount of phosphate mined by the 137 mines considered was 1,231,703 tons, having a value at the mine of $7,153,141. The United States census office informs the Department that the preliminary totals for the phosphate industry of the country show for 1890 a production of 1,225,062 tons of acid phosphate and mineral phosphate fertilizers, valued at $22,308,473; 274,644 tons of fertilizers from raw bone, valued at $6,616,825; and 318,846 tons of other fertilizers, valued at $5,113,154, or a total of all classes of fertilizers of 1,818,552 tons, valued at $34,038,452. In furnishing this information the census office officials wish it to be understood that the data are preliminary and subject to such revision as may be found necessary upon receipt of further information. The only object of using this information in this place is to show the harmony of results relative to the total production of phosphate fertilizers in the United States as exhibited by the census and by this special investigation.

Of the total production, as shown by Tables I and II, given at the close of this chapter, 1,033,409 tons were shipped from the mines.

The number of acres controlled for mining purposes in Florida is 179,848; in North Carolina, 2,500; and in South Carolina, 69,790, or a total of 252,138 acres. The miles of river controlled for mining purposes in Florida are 163½ in 15 mines, 3 mines not reporting; and in South Carolina, 7 in 1 mine, 6 mines not reporting, or a total of 170½ miles in 16 mines, 9 mines not reporting.

The total capital invested in plant in Florida is $2,140,582, and in land, $11,346,067; in North Carolina the plant is represented by $2,000 and the land by $100,000; in South Carolina the plant is worth $2,563,200 and the land $2,920,000. The capital invested, then, in plant (the facts not being given for five mines) is $4,705,782, and in land (the facts not being given for sixteen mines) $14,366,067, or a total of $19,071,849 invested in the phosphate mining of the country.

The total average number of employés engaged in the production of phosphate is 9,175. This, however, does not include all the labor in one mine and the skilled labor in two mines, these facts not being reported. The total expenditure for labor for the period covered was, in

Florida, $881,711; in North Carolina, $1,215; and in South Carolina, $1,590,689, or for the whole, $2,473,615. In this amount is included, in three mines, the expenditure for officials and clerks, which was given by the proprietors, but who declined to separate the amounts. It makes no appreciable difference, however, in the grand total.

The average yearly earnings of employés engaged in production in the land mines of Florida are $211, and in the river mines $347; in the land mines of South Carolina, $287, and in the river mines of that state, $378; in North Carolina the earnings of the employés are now, on an average, $68 per annum. The average in Florida, for both land and river mines, is $225, and in South Carolina, $303, or for the whole industry, $270 per annum.

These details, drawn from the two general tables described, are shown in tabular form, with notes of modifications, omissions, etc., as follows:

QUANTITY AND VALUE OF PHOSPHATE MINED, ACRES CONTROLLED, CAPITAL INVESTED, AND NUMBER AND WAGES OF EMPLOYÉS.

Locality and number of mines.	Phosphate mined.		Quantity shipped (tons of 2,240 pounds).	Controlled for mining purposes.		Capital invested in—		Expenditure for labor.	Employés engaged in production.	
	Quantity (tons of 2,240 pounds).	Value at mine.		Acres.	Miles of river.	Plant.	Land.		Average number.	Average yearly earnings.
Florida:										
88 land mines.	371,190	$2,186,153	268,718	179,848	......	*a*$1,329,582	*b*$9,600,067	*c* $737,557	*d*3,499	$211
18 river mines.	160,837	635,696	151,715	....	*a*163½	*e* 811,000	*a*1,746,000	144,154	416	347
Total...	532,027	2,821,849	420,433	179,348	*a*163½	*f*2,140,582	*g*11,346,067	*c*881,711	*d*3,915	225
N. Carolina:										
1 land mine..	700	2,800	700	2,500	......	2,000	100,000	1,215	18	68
S. Carolina:										
23 land mines.	429,976	2,641,992	379,276	69,790	......	1,272,000	*f*2,865,000	*c*1,239,491	*h*4,314	287
7 river mines.	269,000	*i*1,686,500	233,000	....	*j*7	1,291,200	55,000	*c* 351,198	*h* 928	378
Total...	698,976	*i*4,328,492	612,276	69,790	.*j*7	2,563,200	*f*2,920,000	*k*1,590,689	*l*5,242	303
Grand total...	1,231,703	*i*7,153,141	1,033,409	252,138	*m*170½	*f* 4,705,782	*n*14,366,067	*o*2,473,615	*p*9,175	270

a Not including 3 mines not reporting.
b Not including 8 mines not reporting.
c Including the expenditures for officials and clerks in 1 mine.
d Not including 1 mine not reporting.
e Not including 2 mines not reporting.
f Not including 5 mines not reporting.
g Not including 11 mines not reporting.
h Not including skilled labor in 1 mine not reporting.
i Not including 1 mine with a product of 600 tons not reporting.
j Not including 6 mines not reporting.
k Including the expenditures for officials and clerks in 2 mines.
l Not including skilled labor in 2 mines not reporting.
m Not including 9 mines not reporting.
n Not including 16 mines not reporting.
o Including the expenditures for officials and clerks in 3 mines.
p Not including all labor in 1 mine and skilled labor in 2 mines not reporting.

THE COST OF PRODUCTION.

It has been exceedingly difficult to secure the cost of producing phosphate in the various localities given to its production. From the general tables, however, some summarized facts are obtainable, and these facts are given for land mines in the three states engaged in the industry in the following brief summaries:

SUMMARY OF COST OF PHOSPHATE IN SEVENTY-ONE LAND MINES IN FLORIDA.

[This summary is drawn from sub-tables A to G, pages 110 to 123. The establishments covered are numbers 1 to 3, 5 to 9, 11 to 15, 17 to 25, 28 to 37, 39 to 42, 44, 45, 48, 50, 52 to 55, 57, 59 to 63, 66 to 72, 74 to 85, 87, 88, being all the land mines in Florida from which complete reports of costs have been obtained. The periods covered are twelve months and are in the years 1890, 1891, and 1892.]

Elements of cost.	Tons of 2,240 pounds.	
	Cost of 279,499.	Average cost of one.
Labor	$524,748	$1.878
Officials and clerks	84,522	.302
Supplies and repairs	117,695	.421
Taxes	14,936	.053
Total	741,901	2.654

SUMMARY OF COST OF THEORETICAL ELEMENTS IN THE ABOVE.

[Nineteen establishments gave the amount paid for insurance; fifty-two reported that there was no expenditure for insurance. Six establishments gave the amount paid for interest; sixty-five reported that there was no expenditure for interest. Two establishments gave the amount of depreciation of value of plant; sixty-nine reported that there was no depreciation. Nine establishments gave the amount paid for royalty to owners of the soil; sixty-two reported that there was no expenditure for royalty to owners of the soil. Twenty-five establishments gave the amount paid for transportation to place of free delivery; forty-six reported that there was no expenditure for transportation to place of free delivery. The aggregates entered in the first column below are, of course, apportioned in the second column among the whole seventy-one establishments.]

Elements of cost.	Tons of 2,240 pounds.	
	Cost of 279,499.	Average cost of one.
Insurance	$7,888	$0.028
Interest	11,639	.042
Depreciation of value of plant	6,650	.024
Royalty to owners of the soil	19,290	.069
Transportation to place of free delivery	[a] 600,031	[a] 2.802
Total	645,498	2.965

[a] Based on 214,155 tons, the quantity actually shipped.

SUMMARY OF COST OF PHOSPHATE IN ONE LAND MINE IN NORTH CAROLINA.

[This summary is drawn from sub-tables A to G, pages 110 to 123. The establishment covered is number 89. The period covered is for twelve months and is in the year 1892.]

Elements of cost.	Tons of 2,240 pounds.	
	Cost of 700.	Average cost of one.
Labor	$1,215	$1.736
Officials and clerks	390	.557
Supplies and repairs	500	.714
Taxes	125	.179
Total	2,230	3.186

This establishment reported that there was no expenditure for insurance, interest, royalty to owners of the soil, transportation to place of free delivery, and no depreciation of value of plant.

SUMMARY OF COST OF PHOSPHATE IN TWENTY-TWO LAND MINES IN SOUTH CAROLINA.

[This summary is drawn from sub-tables A to G, pages 110 to 123. The establishments covered are numbers 90 to 111, being all the land mines in South Carolina from which complete reports of costs have been obtained. The periods covered are twelve months and are in the years 1890, 1891, and 1892.]

Elements of cost.	Tons of 2,240 pounds.	
	Cost of 391,576.	Average cost of one.
Labor	$1,095,491	$2.798
Officials and clerks	60,066	.153
Supplies and repairs	199,078	.509
Taxes	14,563	.037
Total	1,369,198	3.497

SUMMARY OF COST OF THEORETICAL ELEMENTS IN THE ABOVE.

[Seventeen establishments gave the amount paid for insurance; five reported that there was no expenditure for insurance. Two establishments gave the amount paid for interest; twenty reported that there was no expenditure for interest. Twenty-two establishments gave the amount of depreciation of value of plant. Five establishments gave the amount paid for royalty to owners of the soil; seventeen reported that there was no expenditure for royalty to owners of the soil. Three establishments gave the amount paid for transportation to place of free delivery; nineteen reported that there was no expenditure for transportation to place of free delivery. The aggregates entered in the first column below are, of course, apportioned in the second column among the whole twenty-two establishments.]

Elements of cost.	Tons of 2,240 pounds.	
	Cost of 391,576.	Average cost of one.
Insurance	$4,920	$0.013
Interest	1,490	.004
Depreciation of value of plant	114,540	.293
Royalty to owners of the soil	33,830	.086
Transportation to place of free delivery	[a]154,000	[a].447
Total	308,780	.843

[a] Based on 344,270 tons, the quantity actually shipped.

In the examination of the foregoing summaries it will be found that, taking the total cost in Florida for the 71 mines covered by the summary, which includes labor, officials and clerks, supplies and repairs, and taxes, the average cost per ton, as shown by the cost for 279,499 tons, is $2.654. Adding to this the cost of insurance, interest, depreciation of value of plant, royalty to owners of the soil, and transportation to place of free delivery, averaging $2.965, it is found that the average total cost of a ton is $5.619 in Florida. The table giving the facts for 22 land mines in South Carolina shows that the average cost of 391,576 tons, for labor, officials and clerks, supplies and repairs, and taxes, is $3.497, while the additional, or what has been called the theoretical elements, consisting of insurance, interest, depreciation of value of plant, royalty to owners of the soil, and transportation to place of free delivery, is $0.843 per ton on an average, or a total cost in South Carolina for phosphate from land mines of $4.34, as against $5.619 per ton, on an average, in Florida. Where this difference occurs will be easily seen by reference to the summaries just given. The cost of labor in mining in South Carolina is greater than in Florida, it being on the average $2.798 per ton, as against $1.878 on the average in Florida, while the cost of transportation in Florida is $2.802 per ton, as against $0.447 in South Carolina. The South Carolina mines are more accessible than those in Florida, a fact which accounts for this great difference. One might inquire, then, why it is that the Florida phosphate, costing $5.619 per ton on the average at the place of free delivery, against a total cost of $4.34 per ton on the average for the South Carolina phosphate, secures a market along with the South Carolina product. The answer is that, while the cost is greater, the percentage of purity or of utility of the Florida product is much greater than that of the South Carolina product, as shown in the tables giving the analyses of the phosphates in the two states in the respective chapters devoted to them.

Looking at the cost of production in river mines, the general tables furnish the following summaries:

SUMMARY OF COST OF PHOSPHATE IN TWELVE RIVER MINES IN FLORIDA.

[This summary is drawn from sub-tables A to G, pages 132 to 135. The establishments covered are numbers 1, 4, 5, 7, 9, 10, 13 to 18, being all the river mines in Florida from which complete reports of costs have been obtained. The periods covered are twelve months and are in the years 1890, 1891, and 1892.]

Elements of cost.	Tons of 2,240 pounds.	
	Cost of 93,737.	Average cost of one.
Labor	$93,637	$0.999
Officials and clerks	38,187	.407
Supplies and repairs	43,373	.463
Taxes	2,164	.023
Royalty to the state	a 5,771	a .062
Total	183,132	1.954

a Ten establishments report having paid no royalty; the right of the state to demand royalty from persons mining unnavigable streams being now in litigation.

SUMMARY OF COST OF THEORETICAL ELEMENTS IN THE ABOVE.

[Ten establishments gave the amount paid for insurance; two reported that there was no expenditure for insurance. Two establishments gave the amount paid for interest; ten reported that there was no expenditure for interest. Three establishments gave the amount of depreciation of value of plant; nine reported that there was no depreciation. Seven establishments gave the amount paid for transportation to place of free delivery; five reported that there was no expenditure for transportation to place of free delivery. The aggregates entered in the first column below are, of course, apportioned in the second column among the whole twelve establishments.]

Elements of cost.	Tons of 2,240 pounds.	
	Cost of 93,737.	Average cost of one.
Insurance	$4,960	$0.053
Interest	1,100	.012
Depreciation of value of plant	6,400	.068
Transportation to place of free delivery	a 240,059	a 2.691
Total	252,519	2.824

a Based upon the actual number of tons shipped.

SUMMARY OF COST OF PHOSPHATE IN FOUR RIVER MINES IN SOUTH CAROLINA.

[This summary is drawn from sub-tables A to G, pages 132 to 135. The establishments covered are numbers 19 to 22, being all the river mines in South Carolina from which complete reports of costs have been obtained. The periods covered are twelve months and are in the years 1890, 1891, and 1892.]

Elements of cost.	Tons of 2,240 pounds.	
	Cost of 119,000.	Average cost of one.
Labor	$113,786	$0.956
Officials and clerks	10,400	.087
Supplies and repairs	33,615	.283
Taxes	3,385	.029
Royalty to the state	119,000	1.000
Total	280,186	2.355

SUMMARY OF COST OF THEORETICAL ELEMENTS IN THE ABOVE.

[Two establishments gave the amount paid for insurance; two reported that there was no expenditure for insurance. Each of the four establishments reported that there was no expenditure for interest and transportation to place of free delivery, and each gave the amount of depreciation of value of plant. The aggregates entered in the first column below are, of course, apportioned in the second column among the whole four establishments.]

Elements of cost.	Tons of 2,240 pounds.	
	Cost of 119,000.	Average cost of one.
Insurance	$1,125	$0.009
Interest	....	....
Depreciation of value of plant	16,250	.137
Transportation to place of free delivery	....	....
Total	17,375	.146

Observing the same divisions as to elements of cost as were observed in the consideration of land mines, it is found that in Florida, for all river mines, covering 93,737 tons, the average cost of one ton is $1.954 for labor, officials and clerks, supplies and repairs, taxes, and royalty to the state. The total cost must be increased, however, by the addition of insurance, interest, depreciation, and transportation, which amount to $2.824, or a total of $4.778 for phosphate from river mines in Florida. In South Carolina the total cost is $2.501, and, as in the case of the land mines, this large difference in cost is caused by the wide difference in cost of transportation to place of free delivery.

In making up Tables I and II and the summaries of cost therefrom, it has been thought best to divide the elements of cost into two specific sections, the first, that relating to labor, officials and clerks, supplies and repairs, taxes, and in river mines royalty to the state, comprehending fixed, absolute, universal elements of cost that all mines must bear, and the other section embracing what have been called theoretical elements, comprehending insurance, interest, depreciation of value of plant, transportation to place of free delivery, and in land mines royalty to owners of the soil. These latter elements have been called theoretical because they are not universally fixed charges, but charges that vary according to location, according to the ideas of proprietors as to insurance, and according to the interest paid in different places and the custom of proprietors in charging interest. These elements have been grouped in different sections, as stated, simply as a matter of statistical integrity. They have been given in full, that all the elements of cost may be readily observed. The details for each establishment reported, from which these summaries are drawn, are given in the long tables I and II, under the various sub-tables, to which reference can be made to ascertain the great variation in all the different items of elements of cost of the production of phosphate. The elements showing the greatest variation are those of labor cost in mining phosphate and in transportation. In the first instance the variation occurs on account of the varying conditions attending the mining. The widest differences are shown in the Florida land mines, as compared with the South Carolina land mines. This results from the fact that in Florida the country is undulating, the depths at which the phosphate is found varying so greatly as to make it impossible to establish even an approximately uniform cost per ton, while in South Carolina the phosphate mines are located on comparatively flat lands, the overburden being more even in depth. The variations in all land mining, however, are greater than those attending river mining. A study of subtable E, in the two tables I and II, in this chapter, discloses the variations attending different localities, for the labor cost is given for each separate mine. As to transportation, the variation takes place, of course, relative to distances.

THE SHIPMENT AND CONSUMPTION OF PHOSPHATE.

The shipment of phosphate clearly indicates its consumption. Effort has been made to secure the shipments of phosphate from the two principal sources of supply, and with success. The figures have been taken from original sources. The first of the two tables following shows the shipments of South Carolina phosphate from 1867 to 1892, inclusive, in tons of 2,240 pounds, from the two principal ports of South Carolina, Beaufort and Charleston. The second table exhibits the total shipments to foreign and domestic markets from the same state and the total annual consumption from 1867 to 1892, in tons of 2,240 pounds.

SHIPMENTS OF SOUTH CAROLINA PHOSPHATE FROM 1867 TO 1892.

[Tons of 2,240 pounds.]

Year.	Beaufort—		Manufactured at home.	Charleston—		Manufactured at home.
	To foreign markets.	To domestic markets.		To foreign markets.	To domestic markets.	
1867	....	....	....	....	6	....
1868	....	....	....	208	11, 654	....
1869	....	....	....	3, 760	24, 511	....
1870	1, 980	664	....	13, 652	40, 099	....
1871	28, 431	5, 064	....	14, 093	16, 843	12, 000
1872	17, 540	3, 180	....	15, 628	25, 955	10, 000
1873	24, 600	4, 765	....	2, 435	27, 403	15, 000
1874	44, 857	10, 500	....	7, 688	31, 930	16, 000
1875	44, 617	7, 000	....	25, 929	25, 560	19, 680
1876	50, 834	9, 400	....	25, 431	28, 831	18, 850
1877	73, 923	6, 285	....	28, 844	40, 768	15, 000
1878	100, 619	8, 217	....	21, 123	60, 729	17, 635
1879	97, 799	8, 618	....	21, 767	52, 281	18, 900
1880	47, 157	13, 346	....	14, 218	94, 012	22, 040
1881	62, 600	65, 895	....	8, 568	91, 929	38, 142
1882	89, 581	57, 645	....	22, 905	111, 314	42, 900
1883	94, 789	36, 175	....	28, 251	150, 545	42, 000
1884	132, 114	34, 711	5, 900	21, 495	187, 700	51, 000
1885	112, 000	32, 000	12, 000	11, 490	161, 700	55, 000
1886	153, 409	14, 600	9, 000	6, 800	187, 000	60, 000
1887	190, 000	15, 905	13, 000	9, 700	182, 000	70, 000
1888	185, 850	29, 834	12, 000	3, 800	208, 000	75, 000
1889	137, 102	60, 000	15, 000	5, 900	248, 643	75, 000
1890	171, 106	49, 890	16, 000	48, 716	201, 046	100, 000
1891	121, 360	42, 846	16, 000	5, 438	252, 305	135, 000
1892	120, 058	40, 602	16, 000	4, 396	202, 340	165, 000
Total	2, 102, 326	557, 142	114, 900	372, 235	2, 665, 104	1, 074, 147

SHIPMENTS AND CONSUMPTION OF SOUTH CAROLINA PHOSPHATE FROM 1867 TO 1892.

[Tons of 2,240 pounds.]

Year.	Shipped to foreign markets.	Shipped to domestic markets.	Manufactured at home.	Total domestic consumption.	Total consumption.
1867	....	6	....	6	6
1868	208	11, 654	....	11, 654	11, 862
1869	3, 760	24, 511	....	24, 511	28, 271
1870	15, 632	40, 763	....	40, 763	56, 395
1871	42, 524	21, 907	12, 000	33, 907	76, 431
1872	33, 168	29, 135	10, 000	39, 135	72, 303
1873	27, 035	32, 168	15, 000	47, 168	74, 203
1874	52, 545	42, 430	16, 000	58, 430	110, 975
1875	70, 546	32, 560	19, 680	52, 240	122, 786
1876	76, 265	38, 231	18, 850	57, 081	133, 346
1877	102, 767	47, 053	15, 000	62, 053	164, 820
1878	121, 742	68, 946	17, 635	86, 581	208, 323
1879	119, 566	60, 899	18, 900	79, 799	199, 365
1880	61, 375	107, 358	22, 040	129, 398	190, 773
1881	71, 168	157, 824	38, 142	195, 966	267, 134
1882	112, 486	168, 959	42, 900	211, 859	324, 345
1883	123, 040	186, 720	42, 000	228, 720	351, 760
1884	153, 609	222, 411	56, 900	279, 311	432, 920
1885	123, 490	193, 700	67, 000	260, 700	384, 190
1886	160, 209	201, 600	69, 000	270, 600	430, 809
1887	199, 700	197, 905	83, 000	280, 905	480, 605
1888	189, 650	237, 834	87, 000	324, 834	514, 484
1889	143, 002	308, 643	90, 000	398, 643	541, 645
1890	219, 822	250, 936	116, 000	366, 936	586, 758
1891	126, 798	295, 151	151, 000	446, 151	572, 949
1892	124, 454	242, 942	181, 000	423, 942	548, 396
Total	2, 474, 561	3, 222, 246	1, 189, 047	4, 411, 293	6, 885, 854

The shipments of Florida phosphate through the United States custom-houses for the years ending December 31, 1891, and December 31, 1892, are given in the following brief statements. The computations have been made on the basis of the long ton of 2,240 pounds. As will be seen, the table shows the port of shipment and kind of phosphate shipped. It also shows the number of tons sent to foreign and to domestic markets. The figures given have been taken from the books of the custom-houses:

SHIPMENTS OF FLORIDA PHOSPHATE THROUGH THE UNITED STATES CUSTOM-HOUSES FOR THE YEAR ENDING DECEMBER 31, 1891.

[Tons of 2,240 pounds.]

Port of shipment.	Hard rock.		River pebble.		Land pebble.		Total.	
	To domestic markets.	To foreign markets.	To domestic markets.	To foreign markets.	To domestic markets.	To foreign markets.	To domestic markets.	To foreign markets.
Fernandina	2,115	50,313					2,115	50,313
Punta Gorda			19,094	35,855			19,094	35,855
Tampa		14,170	4,122	3,200	950		5,072	17,370
Jacksonville	600		1,780				2,380	
Brunswick		2,380						2,380
Savannah		7,230½						7,230½
Total	2,715	74,093½	24,996	39,055	950		28,661	113,148½

As will be seen, the total shipments of Florida phosphate to foreign markets aggregated 113,148½ tons, while the shipments to domestic markets aggregated only 28,661 tons. The total amount shipped through the custom-houses during the year to both domestic and foreign markets was 141,809½ tons.

SHIPMENTS OF FLORIDA PHOSPHATE THROUGH THE UNITED STATES CUSTOM-HOUSES FOR THE YEAR ENDING DECEMBER 31, 1892.

[Tons of 2,240 pounds.]

Port of shipment.	Hard rock.[1]		River pebble.		Land pebble.		Total.	
	To domestic markets.	To foreign markets.	To domestic markets.	To foreign markets.	To domestic markets.	To foreign markets.	To domestic markets.	To foreign markets.
Fernandina	6,553	115,305		5,092			6,553	120,397
Punta Gorda			25,286	50,754			25,286	50,754
Tampa	1,025	34,926	11,096	15,707	14,545	850	26,666	51,483
Brunswick		19,097						19,097
Savannah		7,338						7,338
Total	7,578	176,666	36,382	71,553	14,545	850	58,505	249,069

For the year ending December 31, 1892, the total amount of Florida phosphate shipped through the United States custom-houses is seen to be 307,574 tons, 58,505 tons going to domestic markets and 249,069 tons going to foreign markets.

The following table shows the output of Florida phosphate for each of the years 1888, 1889, 1890, 1891, and 1892, and illustrates the growth and development of the industry. It is made up from actual shipments. The railway lines haul phosphate by the short ton of 2,000 pounds, but their returns have been altered so as to agree with the custom-house reports, which are based on the long ton of 2,240 pounds, The several railway lines are credited only with that which went inland or coastwise from their termini, without clearing. The custom-house clearances account for the balance. Plate rock is included in the hard rock report:

SHIPMENTS OF FLORIDA PHOSPHATE FROM 1888 TO 1892.

[Tons of 2,240 pounds.]

Year.	How shipped.	Hard rock.	Land pebble.	River pebble.	Soft phosphate.	Total.
1883	By rail, inland			813		813
	Total			813		813
1889	By rail, inland	25		3,755		3,780
	Total	25		3,755		3,780
1800	Through custom-house at—					
	Fernandina	9,438				9,438
	Punta Gorda			13,880		13,880
	Tampa			1,800		1,800
	Jacksonville			2,705		2,705
	Savannah	782				782
	By F. C. and P. R. R. and coastwise	6,225				6,225
	By J. T. and K. W. R. R. and coastwise	900		14,951	200	16,051
	Used at home in raw state				1,500	1,500
	Total	17,345		33,336	1,700	52,381
1891	Through custom-house at—					
	Fernandina	52,428				52,428
	Punta Gorda			54,949		54,949
	Tampa	14,170	950	7,322		22,442
	Jacksonville	600		1,780		2,380
	Brunswick	2,380				2,380
	Savannah	7,230½				7,230½
	By F. C. and P. R. R. and coastwise	8,129			5,000	13,129
	By S. F. and W. R. R. and coastwise	2,012				2,012
	By J. T. and K. W. R. R. and coastwise	893	1,725	13,714	240	16,572
	Used at home in raw state				5,544	5,544
	Unclassified	500	250	1,500		2,250
	Total	88,342½	2,925	79,265	10,784	181,316½
1892	Through custom-house at—					
	Fernandina	121,858		5,092		126,950
	Punta Gorda			76,040		76,040
	Tampa	35,951	15,395	26,803		78,149
	Brunswick	19,097				19,097
	Savannah	7,338				7,338
	By F. C. and P. R. R. and coastwise	5,768			400	6,168
	By Plant system and coastwise	10,757				10,757
	By J. T. and K. W. R. R	1,000	1,700	4,778	869	8,347
	Used at home in raw state				6,180	6,180
	Unclassified	250	700	13,459	892	15,301
	Total	202,019	17,795	126,172	8,341	354,327

SUMMARY OF SHIPMENTS OF FLORIDA PHOSPHATE FROM 1888 TO 1892.

[Tons of 2,240 pounds.]

Year.	Hard rock.	Land pebble.	River pebble.	Soft phosphate.	Total.
1888			813		813
1889	25		3,755		3,780
1890	17,345		33,336	1,700	52,381
1891	88,342½	2,925	79,265	10,784	181,316½
1892	202,019	17,795	126,172	8,341	354,327
Grand total	307,731½	20,720	243,341	20,825	592,617½

The most reliable data obtainable show the total consumption of mineral phosphate in the world for the year 1891 to have been 1,587,133½ tons. France, which, next to the United States, is the largest producer, furnished 400,000 tons, or 25.20 per cent., while the United States furnished 757,133½ tons, or 47.70 per cent. The phosphate industry, like other industries, has its seasons of buoyancy and depression, resulting chiefly from agricultural conditions. An estimate of probable consumption in the future, based upon that of the past, should therefore be made for periods long enough to cover both bad and good years. With that in view, the following tables have been prepared, which show the increase in the shipments of phosphate from the mines of South Carolina, grouped by periods of five and ten years:

INCREASE IN SHIPMENTS OF SOUTH CAROLINA PHOSPHATE, BY PERIODS OF FIVE YEARS.

[Tons of 2,210 pounds.]

Periods.	Quantity shipped.	Increase.	Per cent. of increase.
1870 to 1874	386,732	....	....
1875 to 1879	827,955	441,223	114.09
1880 to 1884	1,738,627	910,672	109.99
1885 to 1889	2,435,616	696,989	40.09

INCREASE IN SHIPMENTS OF SOUTH CAROLINA PHOSPHATE, BY PERIODS OF TEN YEARS.

[Tons of 2,240 pounds.]

Periods.	Quantity shipped.	Increase.	Per cent. of increase.
1870 to 1879	1,214,687	....	....
1880 to 1889	4,174,243	2,959,556	243.65

Whether the foregoing facts are considered by five-year or ten-year periods, they show a satisfactory increase in the consumption of phosphate. The market has responded to the new discoveries, and a more abundant supply has stimulated demand by the lowering of prices. In addition to the amounts as shown in the brief tables preceding, Florida high grades are being taken extensively in lieu of that hitherto obtained from other countries. Already it is quite apparent that the percentages of increase for the last five and ten year periods will, as applied to the next five and ten year periods, fall short of the present and prospective demand. Supplementing these statements, those following, which are fully explained by the head-lines, are given as general facts relating to the industry:

THE WORLD'S PRODUCTION OF PHOSPHATE, NOT INCLUDING THE UNITED STATES, FOR 1891, AS ESTIMATED BY MR. HERMANN VOSS.

[Tons of 2,240 pounds.]

Countries producing.	Quantity.
France—Somme and Ardennes	400,000
West Indies—Aruba, etc	50,000
Belgium—Mons and Liege	200,000
Canada	20,000
Germany—Lahn	40,000
England (coprolites)	20,000
Russia, Norway, and other countries	100,000
Total	830,000

THE WORLD'S CONSUMPTION OF PHOSPHATE, NOT INCLUDING THE UNITED STATES, FOR 1891, AS ESTIMATED BY MR. HERMANN VOSS.

[Tons of 2,240 pounds.]

Countries consuming.	Quantity.
United Kingdom of Great Britain	300,000
Germany	250,000
France	150,000
France (in the raw state)	200,000
Belgium and Holland	75,000
Other countries	55,000
Total	1,030,000

An estimate of the world's consumption, based on more accurate figures for the production and shipments of the United States than were accessible to Mr. Voss, is given below. It should be borne in mind, however, that these figures are but estimates, though they are thought to be fairly accurate:

THE WORLD'S CONSUMPTION OF PHOSPHATE, INCLUDING THE UNITED STATES, FOR 1891.

[Tons of 2,240 pounds.]

Countries consuming.	Quantity.
United States	517,187
Countries other than United States	1,069,946½
Total	1,587,133½

THE CONSUMPTION AS INDICATED BY SHIPMENTS OF PHOSPHATE, MINED IN THE UNITED STATES, DURING 1891.

[Tons of 2,240 pounds.]

Where mined.	Quantity shipped.	Average price per ton.	Value.
FOREIGN.			
South Carolina	126,798	$6.50	$824,187.00
Florida	113,148½	9.00	1,018,336.50
Total	239,946½	7.68	1,842,523.50
DOMESTIC.			
South Carolina	446,151	6.50	2,899,981.50
Florida	68,168	7.00	477,176.00
Georgia	2,400	7.00	16,800.00
North Carolina	468	6.50	3,042.00
Total	517,187	6.57	3,396,999.50
Grand total	757,133½	6.92	5,239,523.00

THE WORLD'S PRODUCTION OF PHOSPHATE, INCLUDING THE UNITED STATES, FOR 1891.

[Tons of 2,240 pounds.]

Countries producing.	Quantity.
United States	757,133⅓
Countries other than United States	830,000
Total	1,587,133⅓

Permission has been given the Department to publish an extract from a letter written by Mr. Hermann Voss, a recognized English authority of the highest standing, in October, 1891, and read at a convention of phosphate miners held in Ocala, Florida. The extract gives the prices per unit of phosphate in the English market for the past ten years, and is as follows:

PRICES PER UNIT OF PHOSPHATE IN THE ENGLISH MARKET, 1882 TO 1891.

Year.	South Carolina, 55 to 60 per ct.	Somme, 70 to 80 per cent.	Canadian, 80 to 85 per cent.
1882	$0.26 to $0.30		$0.34
1883	.26 to .28		.32
1884	.20 to .22		$0.24 to .26
1885	.18 to .22		.24 to .26
1886	.17 to .19		.24
1887	.15 to .16	$0.21 to $0.22	.24
1888	.15 to .18	.22 to .23	.23
1889	.21 to .22	.23 to .27	.24 to .26
1890	.20 to .22	.26 to .30	.28 to .30
1891	.20 to .21	.22 to .24	.24 to .26
Average	.19⅘ to .22	.22⅘ to .25⅕	.24⅘ to .27$\frac{1}{10}$

The average percentage of phosphate of lime and the average price per unit, giving the average price per ton of 2,240 pounds in the English market, based on Mr. Voss's table, will be as follows:

AVERAGE PRICE OF PHOSPHATE IN THE ENGLISH MARKET, 1882 TO 1891.

Period, 1882 to 1891, inclusive.	Average percentage of phosphate of lime.	Average price per unit.	Average price per ton of 2,240 pounds.
	Per cent.		
South Carolina	57½	0.20\frac{9}{10}$	$12.01¾
Somme	75	.24	18.00
Canadian	82½	.25$\frac{19}{20}$	21.40⅞

THE COMMERCIAL ASPECT.

A consideration of the growth of the manufacture and consumption of complete commercial fertilizers, in which phosphoric acid, the product of phosphate of lime, is an essential part, is important and within the scope of this investigation; but it has been difficult to obtain accurate statistics of sales in different portions of the country. Bradstreet's for 1892 was able to give official reports from only 5 states, but the Department has secured from official sources the sales in 16 states in the Union, and is able to present the following table:

ANNUAL CONSUMPTION OF COMMERCIAL FERTILIZERS IN VARIOUS STATES FROM 1875 TO 1892.

[Tons of 2,000 pounds.]

State.	1875.	1876.	1877.	1878.	1879.	1880.	1881.	1882.	1883.
Alabama									
Connecticut									
Florida									
Georgia	48,648	55,316	75,824	96,178	85,049	119,588	152,424	125,327	125,377
Indiana									8,000
Kentucky									
Louisiana									
New Jersey								25,631	
New York									
North Carolina									
Ohio									
Pennsylvania									
South Carolina						86,449	109,312	94,817	100,368
Tennessee									
Virginia									
West Virginia									

State.	1884.	1885.	1886.	1887.	1888.	1889.	1890.	1891.	1892.
Alabama	47,651	49,117	45,405	49,255	62,575	71,605	99,818	115,785	84,009
Connecticut				16,700					
Florida						12,194	31,039	35,801	36,933
Georgia	151,849	170,156	160,705	166,078	208,007	202,869	288,112	306,734	196,342
Indiana	6,900	5,860	6,250		10,000	19,300	29,000	26,750	35,000
Kentucky			1,320	5,500	9,100	7,000	7,300	9,950	12,050
Louisiana				6,735	8,199	10,220	11,120	11,371	7,945
New Jersey	42,175	34,003	36,796	32,624	36,085	33,870	42,185	45,168	50,795
New York									90,333
North Carolina								150,000	100,000
Ohio								18,924	20,817
Pennsylvania									128,000
South Carolina	101,048				125,792	131,952	126,000	130,000	110,000
Tennessee						5,688	8,613	13,763	15,909
Virginia								114,119	142,826
West Virginia									25,000

A study of the foregoing figures develops some interesting features. Taking the sales in Georgia for 18 years, in New Jersey for 10 years, and in Indiana for 9 years, the conclusion is that the increase has been common to the South, East, and West, even with their widely diversified crops and conditions. Thus it appears that phosphate is in demand for the cotton crop of the South, for the fruit and vegetable crops of the East, and for the grain crops of the West. Another interesting feature is shown in the variation of the amount consumed in different localities. Looking at the figures for Georgia in the preceding table, it is found that there has been up to 1891 a very steady increase in the use of phosphate, but that for 1892 the consumption fell off materially. This is accounted for by the reduction in the cotton crop, a larger or a smaller crop being due to the amount of phosphate used, and when planters wish to reduce their crop they use less phosphate, even when they cultivate the same acreage. North Carolina shows a falling off also, and for the same reasons; so, too, does South Carolina, and the same features are apparent when the figures for Alabama are considered.

But Florida, for its fruit-raising purposes, increases its consumption. The quantities consumed, as given in the table immediately preceding for the states named, are really under rather than over the full consumption; for only fertilizers purchased from agencies and manufacturers within the states named come under the operation of their laws governing the sale of phosphate.

The value of phosphate if converted into superphosphate has been shown in the chapter relating to Florida.

The following short tables show the shipments of phosphate for the years 1891 and 1892 from all the localities producing it:

SHIPMENTS OF PHOSPHATE IN 1891.

[Tons of 2,240 pounds.]

States producing.	Quantity.	Value.
South Carolina	572, 949	$3, 724, 168. 50
Florida	181, 316½	1, 495, 512. 50
Georgia	2, 400	16, 800. 00
North Carolina	468	3, 042. 00
Total	757, 133½	5, 239, 523. 00

SHIPMENTS OF PHOSPHATE IN 1892.

[Tons of 2, 240 pounds.]

States producing.	Quantity.	Value.
South Carolina	548, 396	$2, 741, 980. 00
Florida	354, 327	2, 537, 054. 61
Georgia	400	2, 400. 00
North Carolina	700	2, 800. 00
Total	903, 823	5, 284, 234. 61

The values given are at the ports.

Of the foregoing, domestic consumers took 517,187 tons in 1891 and 529,200 tons in 1892, which, converted into acid phosphate (in round numbers it would be equivalent to two for one), and valuing the superphosphate at $10.50 per ton, gives the following results: In 1891, 517,187 tons of phosphate converted into 1,034,374 tons superphosphate, would give a total value of $10,860,927. In 1892, 529,200 tons of phosphate converted in 1,058,400 tons superphosphate, would give a total value of $11,113,200.

The total for 1892, $11,113,200, must be considered the commercial value of the modern product of phosphate, the result of a new industry, and yet one that is taking an important place among the mining and manufacturing interests of the country. This statement, however, is found by assuming that if the mineral phosphate consumed in the United States for 1892 had been converted into superphosphate it would equal 1,058,400 tons; but in addition to this there were produced in 1891, according to the report of Mr. David T. Day, chief of the division of mining statistics, United States geological survey, 119,320 long tons of pyrites, used for the production of sulphuric acid, with which the phosphate is dissolved.

The annual report of the chief of the bureau of statistics for the fiscal year ending June 30, 1892, gives the following as among the imports of the country, all of which enter largely into the composition of manufactured fertilizers:

IMPORTS ENTERING INTO THE COMPOSITION OF MANUFACTURED FERTILIZERS.

[Tons of 2,240 pounds.]

Articles.	Number of tons.	Value.
Muriate of potash	31,527	$1,094,122
Nitrate of potash	6,364	435,839
Other potash products	7,502	504,959
Nitrate of soda	109,863	2,976,816
Brimstone or crude sulphur	100,419	2,524,406
Pyrites	136,859	504,897
Bones	23,044	345,668
Guano	4,158	61,264
Phosphate	25,535	162,512
All other fertilizers	71,030	1,207,509
Total	525,301	9,817,992

In the above, domestic bones (raw and dry), blood, fish, scrap, cottonseed meal, etc., all of which are largely utilized in the production of commercial fertilizers, are not included, but they would probably aggregate between 200 and 300 tons. These figures indicate that the production of commercial fertilizers for 1892 can not fall far short of 1,750,000 tons of 2,240 pounds, and these fertilizers, delivered to the consumer at his nearest station, cost from $15 to $65 per ton, but they will average about $30, thus making a total cost of about $52,500,000 for the year 1892 of the commercial fertilizers which had entered into consumption in this country.

ROYALTIES.

Royalties are paid to the state of South Carolina in accordance with the quantity of phosphate mined. These royalties for the years from 1870 to 1892, inclusive, are given in the following table:

ROYALTIES PAID INTO THE TREASURY OF THE STATE OF SOUTH CAROLINA ON PHOSPHATE FROM 1870 TO 1892.

Year.	Royalty.	Year.	Royalty.	Year.	Royalty.
1870	$1,989	1879	$98,586	1888	$186,994
1871	17,655	1880	65,314	1889	212,102
1872	22,502	1881	124,555	1890	237,149
1873	45,777	1882	140,772	1891	185,000
1874	57,716	1883	125,793	1892	184,502
1875	57,969	1884	153,798		
1876	81,912	1885	176,755	Total	2,805,971
1877	126,569	1886	196,090		
1878	97,700	1887	208,772		

The state treasury has therefore gained immensely through the discovery of phosphate and the working of the mines. The people have had their taxes reduced from what they would have been by the amount of $2,805,971 during the period named, or the state has been enabled to use that amount in addition to its ordinary taxes for its improvements.

THE OPPORTUNITIES FOR LABOR.

As shown in the summarized table printed on page 91, it was seen that the average number of employés engaged in the production of phosphate was 9,175, of which 3,915 were employed in Florida, 18 in North Carolina, and 5,242 in South Carolina. The total amount of money expended for the labor of this large number of persons was $2,473,615. This amount represents actual earnings, and the average earnings in the different mines for the different states for the period covered by the investigation, one year, are as follows: In Florida, for land miners, $211, and for river miners, $347; for land miners in North Carolina, $68; and in South Carolina the land miners earned $287, and the river miners $378. The average for all classes for all the states considered was $270 per annum. The higher average earnings for river miners is due to the fact that more skill and experience are necessary in this class of mining than in land mining. Sub-tables J in Tables I and II, given at the close of this chapter, show the rates of wages paid in each of the general occupations attending mining operations. Summarizing these, we find that the average wages paid in different occupations are as follows:

SUMMARY OF RATES OF WAGES, BY OCCUPATIONS.

Occupation.	Average number of employés.	Daily rate of pay, or average daily earnings.
In 87 land mines in Florida.		
Blacksmiths	11	$1.85½
Blaster	1	1.25
Captain, dredge	1	3.83½
Carpenters	24	1.99
Dredgemen	3	1.25
Engineers	66	1.98½
Engineers, assistant	14	1.20½
Engineers, locomotive	2	1.32½
Firemen	24	1.33½
Foremen	156	1.93½
Machinists	10	2.45½
Mechanics	4	1.81½
Mill hands	2	1.53½
Miners and laborers	2,974	1.04
Stablemen	4	1.16
Teamsters	123	1.05
Washers	9	1.25
Watchmen	21	1.13
Water boys	49	.58½
Winchman	1	1.50
In 1 land mine in North Carolina.		
Miners and laborers	18	.75
In 23 land mines in South Carolina (a).		
Blacksmiths	11	1.45½
Carpenters	13	1.63
Chief engineer and mechanic.	1	4.16½
Dipper tender	1	2.00
Dumpers	41	1.02
Engineers	27	2.27½
Engineer, excavator	1	2.39½
Engineers, locomotive	21	1.82
Firemen	39	1.18½
Foremen	15	2.73½
Laborers, railroad	24	1.00
Machinists	2	2.54½
In 23 land mines in South Carolina (a)—Conc'd.		
Miners and laborers	4,090	$1.00½
Sorters	2	1.00
Trackmen	26	.98
In 18 river mines in Florida.		
Captains, dredge, etc	19	2.13½
Carpenters	8	2.33½
Cooks	5	.96
Dredgemen	9	1.43½
Dumpers	3	1.16½
Elevator men	4	1.25
Engineers	45	2.26
Engineer, locomotive	1	2.50
Feeders	2	1.44
Firemen	27	1.42
Foremen	15	2.63½
Laborers	228	1.22
Lightermen	16	1.14
Machinists	4	3.48½
Mates	3	1.51
Mill hands	2	1.53½
Nozzlemen	4	1.36½
Oiler	1	1.20
Pumpers	2	1.00
Teamsters	5	1.00
Watchmen	13	1.34½
In 7 river mines in South Carolina (a).		
Captain, tug	1	3.83½
Dumpers	6	1.00
Engineers	14	3.24
Engineers, machinists, etc	25	3.26
Firemen	9	1.11½
Foremen	8	3.85½
Laborers	862	1.10
Machinists	3	2.81½

[a] Skilled labor not reported in one mine.

In addition to the amount paid in wages to the miners, all of which has been added to the economic condition in the states producing phosphate, there has been quite a sum paid to longshoremen at the several ports for removing ballast and loading ships. This is estimated for 1892, to be $44,802.45 for South Carolina, and for Florida, including the Brunswick and Savannah ports, $76,893.50, or a total paid for this class of labor of $121,695.95 in the year 1892. The wage cost of manipulating and loading the 529,200 tons of phosphate, which is shown to have been used in the United States, and which at the ratio of two to one would give 1,058,400 tons of superphosphate, would at an estimated average of $1.50 per ton give $1,587,600 in the year 1892. We have, then, as the addition to the wage-earning capacity in the phosphate-producing states for the year named the following items:

Wages paid in the mines for the year 1892	$2,473,615.00
Wages paid longshoremen	121,695.95
Wages paid for manipulating and converting into superphosphate	1,587,600.00
Total	4,182,910.95

It should be borne in mind that this large sum is due entirely to the new industry of phosphate mining and is a constant yearly addition to the economic force of the 3 states in which the industry is carried on. In addition to this, the laborer is the beneficiary of the wage cost of transportation, drayage, warehousing, and other handlings, which in the aggregate must amount to a very considerable sum. Of course labor's share growing out of this industry does not stop with these items, for its share goes to the fields, includes the farmer in his multiplied crops, comprehends flour mills, tobacco factories, sugar refineries, and, most important of all, the cotton mills, where the greatly increased product through the use of phosphate is constantly increasing the demand for labor. All these elements add tens of thousands of dollars more to labor's share in the industry. This large addition to the economic force of the states engaged in the industry will be still further increased through the continued opportunities for the employment of labor, while for the investment of capital the industry offers most excellent opportunities, the growing demand insuring, as it does, a profitable return, and the indestructible character of phosphate, which suffers no deterioration, loss, or damage from exposure to the elements, whether in the ground or out of it, makes it a safe investment. These further opportunities are best illustrated by considering the quantity of phosphate in sight.

The Department has taken the greatest pains to ascertain the future opportunities for labor by collecting information as to the amount of phosphate which it may reasonably be expected can be taken from the mines. Dr. Wyatt, in Phosphates of America, gives the lowest estimate for South Carolina, in round numbers, as 14,000,000 tons in sight. This estimate is based on the present rate of production, which he thinks will extend over 28 years from 1891. Capt. James F. Tucker of the Department of Labor, who has collected nearly all the material for this report, and who is thoroughly conversant with the conditions in Florida, estimates the quantity of phosphate in sight in that state to be 133,056,416 tons; and for North Carolina, Georgia, and other states 1,000,000 tons. Capt. Tucker has based his estimate not only upon the most careful personal observation of the whole field, but upon information drawn from conservative and skilled experts and others who, while interested in the state, are not interested in the business of phosphate mining, and, furthermore, in many cases from actual measurements. His estimate, therefore, can be considered as conservative and below the real facts rather than above. The endeavor has been to avoid all the exaggerations which come from speculative estimates, and to secure only those judgments which are based upon absolute knowledge. These various estimates show a grand total of 148,056,416 tons of phosphate in sight, and exhibit better than any text statement can the future opportunities for the employment of labor in the phosphate mining industry of the United States. No discoveries of any considerable quantities of phosphate have been made during the past two years. Of course it is impossible to say what developments will take place in the future in the way of discoveries. The opportunities for labor, therefore, have been considered solely with reference to the existing conditions.

GENERAL TABLES.

The statistics of the cost of production and rates of wages relating to the phosphate industry of the United States are given in two tables, designated I and II. Table I relates to the land mines, and Table II to the river mines. Each table has nine sub-tables, with titles as follows:

A.—Period covered and quantity of product.
B.—General description, capital invested, etc.
C.—Distance, means, and cost of transportation.
D.—General statement of cost for the period.
E.—Elements of cost in one ton of 2,240 pounds.
F.—Per cent. of each element of cost in one ton of 2,240 pounds.
G.—Additional cost of certain theoretical elements for the period.
H.—Additional cost of certain theoretical elements in one ton of 2,240 pounds.
J.—Rates of wages.

These tables are the ones referred to in the preceding part of this chapter, and from which many of the facts cited have been summarized. In Tables I and II the numbers given to establishments run consecutively, in Table I from 1 to 112, land mines, and in Table II from 1 to 25, river mines. The establishment numbers in each table represent the same establishments through all the sub-tables. For instance, in Table I the establishment designated as No. 2, in sub-table A, is the same establishment in each of the succeeding sub-tables. To use the table, therefore, by studying the facts relating to establishment No. 2, land mines, as given in Table I, one would find in sub-table A the period covered and the quantity of product of that establishment. He would also learn that that particular establishment is located in Florida; that the facts collected are for the year ending December 1, 1892; that the mine was operated 120 days during that year; that it is a hard rock mine, the product having 80 per cent. of bone phosphate; that it produced during the time named 1,500 tons of phosphate, of a value of $7,250 at the mine; and that out of the 1,500 tons mined 1,400 tons were shipped. Turning now to sub-table B of the same table, one would find for the same mine, establishment No. 2, that the average depth of deposit from the surface is 8 feet, the average thickness of the deposit being 25 feet; that improved appliances are used in operating the mine; that the deposits are found in pockets; and that the establishment controls for mining purposes 120 acres of land, and has $5,300 invested in plant and $3,200 invested in land. Turning to sub-table C, we shall find for the same establishment, No. 2, that it is 4¼ miles from the primary shipping point which is situated on a railroad; in the case of this establishment the place of free delivery to the purchaser is identical with the primary shipping point.

Following out the study, by turning to sub-table D, it will be found that the labor for establishment No. 2 for the year given cost $1,875, and supplies and repairs $433, the total cost being $2,308, while the elements of cost in one ton of 2,240 pounds will be found from sub-table E, from which it is ascertained that the labor cost of one ton of phosphate mined by this particular establishment was $1.25, and supplies and repairs $0.289, or a total cost per ton of $1.539. Sub-table F gives the percentage which each element of cost is of the total cost per ton, while sub-table G gives the additional cost of certain theoretical elements for the period named. Sub-table H gives the additional cost of these elements as shown per ton, and from this we learn that from the particular mine used for illustration, establishment No. 2, the transportation to place of free delivery cost 50 cents per ton. Sub-table J gives the rates of wages paid in each mine for each of the subdivisions of occupations of the persons employed therein. These statements show clearly, without further analysis, how Table I, relating to land mines, should be used. It is sufficient to remark that Table II, relating to the cost of production and rates of wages of river mines, is to be used in precisely the same way.

TABLE I.—COST OF PRODUCTION OF PHOSPHATE IN THE UNITED STATES, 1890-1892—LAND MINES.

A.—PERIOD COVERED AND QUANTITY OF PRODUCT.

Establishment number.	Locality.	Period covered.		Phosphate mined.				Quantity shipped (tons of 2,240 pounds).
		Year ending—	Days of running time.	Description.	Per cent. of bone phosphate.	Quantity (tons of 2,240 pounds).	Value at mine.	
1	Florida	Oct. 31, 1891	36	Hard rock	81.00	250	$1,500	....
2	....do	Dec. 1, 1892	120	Hard rock	80.00	1,500	7,250	1,400
3	....do	Dec. 1, 1892	130	Hard rock	80.20	500	2,500	300
4	....do	Dec. 1, 1892	180	Hard rock	80.50	1,800	10,800	....
5	....do	Dec. 1, 1892	200	Hard rock	78.90	6,500	32,500	6,500
6	....do	Oct. 1, 1892	200	Hard rock	78.15	4,000	20,000	....
7	....do	Nov. 1, 1891	78	Hard rock	75.16	2,800	19,600	....
8	....do	Dec. 31, 1892	175	Hard rock	80.00	700	3,850	400
9	....do	May 31, 1892	120	Hard rock	80.00	1,100	6,000	1,100
10	....do	Aug. 1, 1892	50	Hard rock	76.00	850	5,100	850
11	....do	Dec. 31, 1892	300	Hard rock	80.00	15,000	95,000	14,000
12	....do	May 30, 1891	150	Hard rock	80.00	2,750	16,500	....
13	....do	Nov. 30, 1892	156	Hard rock	80.00	6,000	30,000	4,500
14	....do	Apr. 1, 1891	114	Hard rock	75.00	1,500	13,500	1,500
15	....do	July 15, 1892	68	Hard rock	82.00	278	1,700	238
16	....do	Sept. 15, 1891	36	Hard rock	82.00	500	3,450	500
17	....do	Apr. 15, 1892	182	Hard rock	70.00	600	3,360	550
18	....do	Dec. 31, 1891	42	Hard rock	72.00	125	1,000	....
19	....do	Dec. 1, 1892	50	Hard rock	80.00	525	2,835	250
20	....do	Dec. 1, 1892	105	Hard rock	80.54	800	5,200	....
21	....do	July 31, 1891	62	Hard rock	79.00	700	4,550	....
22	....do	Oct. 31, 1892	120	Hard rock	77.00	1,000	7,000	500
23	....do	Oct. 31, 1892	96	Hard rock	80.00	1,000	5,400	....
24	....do	Dec. 31, 1892	210	Hard rock	78.00	4,000	22,320	3,000
25	....do	Nov. 30, 1891	234	Hard rock	78.00	12,700	92,000	12,000
26	....do	Dec. 1, 1892	250	Hard rock	78.24	4,000	22,185	3,465
27	....do	Oct. 1, 1892	275	Hard rock	75.15	7,500	41,250	7,500
28	....do	Dec. 1, 1892	275	Hard rock	78.13	9,000	58,500	9,000
29	....do	Sept. 30, 1892	208	Hard rock	79.25	12,000	65,480	11,000
30	....do	Sept. 30, 1891	104	Hard rock	80.00	2,000	10,000	....
31	....do	Dec. 10, 1891	78	Hard rock	80.00	1,000	5,600	900
32	....do	July 31, 1892	234	Hard rock	78.00	3,000	18,000	3,000
33	....do	July 31, 1892	150	Hard rock	80.00	1,900	9,690	983
34	....do	Dec. 31, 1892	300	Hard rock	81.38	38,000	281,160	34,843
35	....do	Dec. 31, 1892	30	Hard rock	79.00	1,500	6,000	....
36	....do	Dec. 31, 1892	234	Hard rock	83.58	6,500	42,510	6,500
37	....do	Oct. 31, 1891	150	Hard rock	75.00	1,200	7,800	1,200
38	....do	Nov. 1, 1892	300	Hard rock	80.00	15,000	90,000	6,000
39	....do	Dec. 31, 1892	273	Hard rock	80.00	9,000	50,310	9,000
40	....do	Dec. 31, 1892	300	Hard rock	79.94	24,150	156,975	19,190
41	....do	Dec. 31, 1892	210	Hard rock	82.63	8,000	44,000	5,500
42	....do	Sept. 1, 1892	132	Hard rock	82.30	14,000	84,000	9,400
43	....do	Dec. 1, 1892	250	Hard rock	81.22	3,000	16,500	2,432
				Gravel screenings	83.00	12,000	66,000	2,025
44	....do	Dec. 21, 1892	30	Hard rock	78.15	300	1,500	....
				Gravel screenings	76.93	450	2,250	450
45	....do	Oct. 20, 1892	200	Hard rock	78.32	2,400	15,000	2,000
				Gravel screenings	76.18	600	2,500	300
46	....do	Dec. 31, 1890	120	Hard rock	80.00	800	4,000	....
				Gravel screenings	80.00	1,500	7,500	....
47	....do	Nov. 15, 1892	200	Hard rock	78.00	800	15,000	2,000
				Gravel screenings	78.00	1,700		
48	....do	Nov. 30, 1892	150	Hard rock	77.00	3,000	18,000	3,000
				Gravel screenings	77.00	4,500	27,000	....
49	....do	Dec. 1, 1892	234	Hard rock	78.00	2,500	15,000	2,500
				Gravel screenings	74.00	1,500	9,000	1,500
50	....do	July 1, 1892	130	Hard rock	78.56	650	3,250	650
				Gravel screenings	70.00	250	1,250	....
51	....do	Dec. 1, 1892	104	Hard rock	80.00	2,000	13,000	400
				Gravel screenings	80.00	1,000	5,000	....
52	....do	Dec. 1, 1892	169	Hard rock	78.50	6,000	39,000	5,350
				Gravel screenings	78.50	1,200	7,200	....
53	....do	Dec. 31, 1892	75	Hard rock	80.15	1,350	7,425	....
				Gravel screenings	82.11	850	3,825	....
54	....do	Dec. 31, 1892	208	Hard rock	83.82	1,800	13,482	1,600
				Gravel screenings	80.00	1,800	7,200	....
55	....do	Jan. 15, 1892	192	Hard rock	77.00	780	5,070	780
				Gravel screenings	77.00	300	1,200	....
56	....do	Aug. 31, 1892	260	Hard rock	80.00	5,000	30,000	5,000
				Gravel screenings	78.00	6,000	28,500	1,000

TABLE I.—COST OF PRODUCTION OF PHOSPHATE IN THE UNITED STATES, 1890-1892—LAND MINES—Continued.

A.—PERIOD COVERED AND QUANTITY OF PRODUCT—Concluded.

Establishment number.	Locality.	Period covered.		Phosphate mined.				Quantity shipped (tons of 2,240 pounds).
		Year ending—	Days of running time.	Description.	Per cent. of bone phosphate.	Quantity (tons of 2,240 pounds).	Value at mine.	
57	Florida	Jan. 15, 1892	78	Hard rock	79.00	1,200	$7,200	....
				Gravel screenings.	79.00	1,200	6,000	....
58	....do	Dec. 31, 1892	300	Hard rock	79.00	16,941	84,705	14,941
				Gravel screenings.	78.00	2,000	10,000	....
59	....do	Dec. 31, 1892	36	Hard rock	80.00	500	3,000	....
				Gravel screenings.	80.00	250	1,500	....
60	....do	Dec. 31, 1892	54	Soft phosphate ...	62.69	300	1,930	....
61	....do	Dec. 1, 1892	156	Soft phosphate ...	68.02	2,000	12,000	2,000
62	....do	Dec. 7, 1892	300	Soft phosphate ...	48.83	2,500	17,500	2,500
63	....do	Nov. 30, 1891	78	Hard rock	80.00	200	1,520	200
				Soft phosphate ...	67.50	150	450	....
64	....do	Dec. 1, 1892	155	Hard rock	77.50	700	4,550	700
				Soft phosphate ...	55.00	100	600	100
65	....do	Dec. 31, 1892	104	Hard rock	75.00	300	1,500	50
				Soft phosphate ...	60.00	1,000	8,000	400
66	....do	Mar. 1, 1892	54	Hard rock	79.00	200	1,200	....
				Soft phosphate ...	60.00	175	512	....
67	....do	Dec. 31, 1892	285	Hard rock	82.00	400	3,200	400
				Soft phosphate ...	55.00	1,600	8,000	1,600
68	....do	July 1, 1892	200	Hard rock	82.50	2,750	19,250	1,700
				Gravel screenings.	76.10	575	1,869	575
				Soft phosphate ...	61.00	350	1,050	350
69	....do	Oct. 31, 1892	125	Hard rock	78.00	300	1,050	300
				Gravel screenings.	78.00	300	1,050	....
				Soft phosphate ...	70.00	400	1,200	380
70	....do	Nov. 1, 1891	42	Hard rock	80.00	300	1,800	....
				Gravel screenings.	80.00	100	450	....
				Soft phosphate ...	80.05	100	300	....
71	....do	Nov. 1, 1892	52	Plate rock	77.00	500	2,500	375
72	....do	Dec. 31, 1892	110	Plate rock	78.00	1,350	6,750	....
73	....do	Dec. 31, 1892	40	Plate rock	75.00	200	1,000	200
74	....do	Dec. 1, 1892	120	Plate rock	77.00	600	3,450	450
75	....do	July 31, 1891	182	Plate rock	77.17	3,000	22,500	3,000
76	....do	Dec. 31, 1892	39	Plate rock	77.50	800	4,000	500
77	....do	Dec. 31, 1892	18	Plate rock	77.50	200	1,000	....
78	....do	Dec. 31, 1892	39	Plate rock	77.35	325	1,870	325
79	....do	Aug. 1, 1892	78	Plate rock	77.00	600	3,600	600
80	....do	Dec. 31, 1892	65	Plate rock	77.39	1,100	5,225	....
81	....do	Dec. 15, 1892	104	Plate rock	75.00	4,100	22,550	4,100
82	....do	Oct. 1, 1892	180	Plate rock	75.00	5,000	25,000	5,000
83	....do	Dec. 1, 1892	150	Land pebble	62.00	450	3,375	100
84	....do	Dec. 31, 1892	150	Land pebble	72.58	5,816	30,170	5,816
85	....do	Dec. 1, 1892	85	Land pebble	71.20	5,000	23,250	....
86	....do	Dec. 1, 1892	150	Land pebble	67.95	3,000	9,000	3,000
87	....do	Dec. 1, 1892	150	Land pebble	76.55	3,000	12,000	3,000
88	....do	Nov. 1, 1892	200	Land pebble	76.49	10,000	36,500	10,000
89	North Carolina .	Dec. 31, 1892	90	Land rock	43.00	700	2,800	700
90	South Carolina..	Dec. 31, 1891	305	Land rock	60.00	20,000	130,000	16,500
91	....do	Aug. 31, 1891	300	Land rock	61.00	5,000	24,500	5,000
92	....do	Dec. 31, 1891	300	Land rock	61.00	12,000	78,000	12,000
93	....do	May 31, 1892	300	Land rock	60.00	25,000	162,500	23,000
94	....do	Aug. 31, 1891	300	Land rock	62.00	10,000	65,000	7,500
95	....do	Dec. 31, 1891	208	Land rock	60.00	9,776	63,544	9,776
96	....do	Feb. 29, 1892	150	Land rock	62.50	13,000	62,000	3,000
97	....do	Dec. 31, 1891	300	Land rock	63.70	6,500	42,250	5,500
98	....do	Dec. 31, 1891	175	Land rock	60.00	10,000	65,000	8,000
99	....do	Dec. 31, 1891	225	Land rock	60.00	21,000	115,500	10,000
100	....do	Dec. 31, 1891	208	Land rock	60.00	3,000	15,300	3,000
101	....do	Dec. 31, 1891	300	Land rock	60.00	18,000	117,000	10,000
102	....do	Dec. 31, 1891	300	Land rock	55.00	4,500	29,250	4,500
103	....do	Dec. 31, 1891	300	Land rock	60.00	20,000	130,000	20,000
104	....do	Dec. 31, 1891	300	Land rock	60.00	25,000	162,500	30,000
105	....do	Dec. 31, 1891	300	Land rock	60.00	24,000	156,000	22,000
106	....do	Dec. 31, 1891	300	Land rock	55.00	10,000	65,000	7,000
107	....do	Mar. 31, 1892	300	Land rock	60.00	18,000	117,000	15,000
108	....do	Mar. 26, 1892	300	Land rock	60.00	85,000	552,500	75,000
109	....do	Dec. 31, 1891	280	Land rock	60.00	13,000	84,500	10,000
110	....do	Dec. 31, 1891	260	Land rock	58.00	10,000	65,000	7,500
111	....do	Aug. 31, 1892	300	Land rock	62.00	28,800	105,408	40,000
112	....do	(*a*)	300	Land rock	60.00	38,400	234,240	35,000

[a] Reported for one year but dates not given.

TABLE I.—COST OF PRODUCTION OF PHOSPHATE IN THE UNITED STATES, 1890-1892—LAND MINES—Continued.

B.—GENERAL DESCRIPTION, CAPITAL INVESTED, ETC.

Establishment number.	Average depth of deposit from surface (feet).	Average thickness of deposit (feet).	Improved appliances used?	Deposit found in—	Acres controlled for mining purposes.	Capital invested in—	
						Plant.	Land.
1	....	15	No	Pockets	160	$1,200	(a)
2	8	25	Yes	Pockets	120	5,300	$3,200
3	6	25	Yes	Pockets	1,360	3,400	100,000
4	....	60	No	Pockets	80	(a)	(a)
5	....	25	Yes	Pockets	1,900	10,000	70,000
6	3½	28	No	Pockets	1,360	500	100,000
7	8	20	Yes	Pockets	640	8,000	50,000
8	6½	45	No	Pockets	6,000	b 10,000	30,000
9	5	25	No	Pockets	160	2,500	10,000
10	12	40	No	Pockets	800	20,000	100,000
11	7½	35	Yes	Pockets	4,600	25,000	45,000
12	....	(a)	Yes	Pockets	800	20,000	(a)
13	....	45	Yes	Pockets	1,350	4,000	150,000
14	1	15	No	Pockets	1,200	5,000	175,000
15	2	12	No	Pockets	110	672	6,000
16	9	15	No	Pockets	40	2,000	15,000
17	5	5	No	Pockets	40	300	4,000
18	7	15	No	Pockets	10	500	3,000
19	10	20	No	Pockets	360	980	5,000
20	4	20	Yes	Pockets	749	4,871	187,500
21	10	20	No	Pockets	120	800	12,000
22	2½	10	No	Pockets	51	1,000	6,000
23	4½	4½	No	Pockets	800	1,500	40,000
24	1	15	No	Pockets	80	4,000	(a)
25	8	40	Yes	Pockets	2,000	45,000	200,000
26	8	25	Yes	Pockets	2,000	15,000	100,000
27	3½	30	No	Pockets	7,000	1,500	125,000
28	11	25	Yes	Pockets	600	25,000	50,000
29	6	30	Yes	Pockets	20,000	55,000	535,000
30	7½	20	No	Pockets	8,000	2,000	250,000
31	4½	16	No	Pockets	1,135	3,000	20,000
32	3	27	No	Pockets	204	2,000	30,000
33	7	17	No	Pockets	40	1,000	10,000
34	17	60	Yes	Pockets	18,000	100,000	1,192,000
35	3	(a)	No	Pockets	10,000	(a)	80,000
36	2	20	Yes	Pockets	7,000	20,000	500,000
37	6	15	No	Pockets	15	700	3,000
38	5	40	Yes	Pockets	1,500	15,000	35,000
39	10	20	Yes	Pockets	36,000	50,000	2,000,000
40	4	25	Yes	Pockets	743	45,493	216,450
41	5	40	Yes	Pockets	1,500	20,000	75,000
42	....	30	No	Pockets	2,080	9,300	200,000
43	11½	25	Yes	Pockets	1,600	16,000	100,000
44	3	15	Yes	Pockets	120	6,000	3,500
45	13	10	No	Pockets	5,000	2,500	25,000
46	....	30	No	Pockets	8,300	2,000	150,000
47	....	30	Yes	Pockets	300	10,000	30,000
48	....	40	No	Pockets	230	(a)	(a)
49	3	15	Yes	Pockets	40	8,000	12,000
50	5	15	No	Pockets	20	700	5,000
51	10	20	Yes	Pockets	1,000	50,000	200,000
52	5	20	Yes	Pockets	2,500	6,000	300,600
53	3	12	No	Pockets	2,000	2,500	(a)
54	5	25	No	Pockets	240	4,000	36,000
55	4	10	No	Pockets	40	4,000	3,000
56	7½	10	Yes	Pockets	920	20,000	125,000
57	5	18	No	Pockets	2,903	11,000	500,000
58	20	24	No	Pockets	1,450	10,000	190,000
59	7	28	Yes	Pockets	927	100,000	75,000
60	2	21	No	Pockets	80	5,600	8,000
61	3	30	Yes	Pockets and veins	550	25,000	35,000
62	4	17½	Yes	Pockets	312	10,000	30,000
63	3	14	No	Pockets	440	150	35,000
64	10	4	Yes	Pockets	108	6,000	15,000
65	3	15	Yes	Pockets	200	8,000	20,000
66	10	10	No	Pockets	55	1,000	10,000
67	4	8	No	Pockets and strata	1,600	2,000	200,000
68	7½	25	No	Pockets	1,930	10,000	175,000
69	....	30	No	Pockets	50	2,500	2,000
70	4	10	No	Pockets	40	1,500	4,000
71	1½	10	Yes	Pockets	560	8,000	(a)

a Not reported.

b Value of plant now being put in.

TABLE I.—COST OF PRODUCTION OF PHOSPHATE IN THE UNITED STATES, 1890-1892—LAND MINES—Continued.

B.—GENERAL DESCRIPTION, CAPITAL INVESTED, ETC.—Concluded.

Establishment number.	Average depth of deposit from surface (feet).	Average thickness of deposit (feet).	Improved appliances used?	Deposit found in—	Acres controlled for mining purposes.	Capital invested in—	
						Plant.	Land.
72	15	15	Yes	Pockets	58	$12,000	$15,000
73	4	10	No	Pockets	15	5,000	10,000
74	2½	6	Yes	Pockets	40	5,000	(a)
75	3	25	Yes	Pockets	1,100	20,000	85,000
76	3	10	Yes	Pockets	240	15,000	10,000
77	3½	10	Yes	Pockets	240	15,000	10,000
78	5	25	Yes	Pockets	290	8,000	12,000
79	4	20	Yes	Pockets and strata	441	20,000	75,000
80	15	10	Yes	Pockets	60	25,000	4,000
81	6	9	Yes	Pockets and strata	200	25,000	75,000
82	8	(a)	Yes	Pockets	500	25,000	30,000
83	2	14	No	Pockets	200	3,000	10,000
84	5	25	Yes	Pockets	728	51,616	22,417
85	4	35	Yes	Pockets	5,000	116,000	100,000
86	4	10	Yes	Pockets and strata	300	25,000	30,000
87	2½	10	Yes	Pockets and veins	714	25,000	50,000
88	3	10	Yes	Pockets	440	60,000	46,000
89	7	(a)	No	Pockets	2,500	2,000	100,000
90	7	1⅓	Yes	Veins	6,200	75,000	100,000
91	8½	¾	Yes	Strata	500	10,000	25,000
92	5	1¼	Yes	Veins and strata	350	50,000	40,000
93	4½	¾	Yes	Veins and strata	3,000	50,000	25,000
94	8	1	Yes	Veins	500	30,000	25,000
95	10	1½	Yes	Veins	440	25,000	15,000
96	7	1½	No	Veins	600	30,000	(a)
97	7	⅝	Yes	Veins	2,300	25,000	15,000
98	6	⅝	Yes	Veins	700	19,000	(a)
99	5½	1⅛	Yes	Strata	5,000	30,000	70,000
100	8	1	Yes	Veins and strata	500	20,000	(a)
101	8	$\frac{7}{12}$	Yes	Veins	600	15,000	(a)
102	9	$\frac{1}{12}$	Yes	Strata	2,500	25,000	100,000
103	8	1⅓	Yes	Veins and strata	700	40,000	75,000
104	6	1⅓	Yes	Strata	500	100,000	50,000
105	6	1¼	Yes	Veins and strata	300	25,000	50,000
106	5	1	Yes	Veins	4,100	25,000	15,000
107	5	1⅛	Yes	Veins	4,000	70,000	5,000
108	5	1	Yes	Strata	20,000	350,000	2,000,000
109	7	1	Yes	Veins	800	50,000	50,000
110	6½	1	Yes	Veins	300	25,000	5,000
111	8	1½	Yes	Veins	900	83,000	(a)
112	6	1¼	Yes	Strata	15,000	100,000	200,000

(a) Not reported.

TABLE I.—COST OF PRODUCTION OF PHOSPHATE IN THE UNITED STATES, 1890-1892—LAND MINES—Continued.

C.—DISTANCE, MEANS, AND COST OF TRANSPORTATION.

Establishment number.	Primary shipping point.		Cost of transportation per ton of 2,240 pounds.				Place of free delivery to purchaser.	
	Miles from mine.	On railroad or river.	From mine to railroad or river station.	From railroad or river station to port of shipment out of state.	From port of shipment out of state to—		Miles from mine.	Cost of transportation per ton of 2,240 pounds.
					Domestic selling port.	Foreign selling port.		
1	⅛	Railroad	(a)	$2.80	(a)	(a)	(a)	(a)
2	4¼	Railroad	$0.50	(a)	(a)	(a)	4¼	$0.50
3	4½	Railroad	(a)	(a)	(a)	(a)	(a)	(a)
4	....	Railroad	....	2.48	(a)	(a)	(a)	(a)
5	4	Railroad	b.45	2.00	$2.65	$4.32	250	2.00
6	4	Railroad	.50	2.80	(a)	(a)	(a)	(a)
7	....	Railroad	....	2.80	(a)	(a)	(a)	(a)
8	....	Railroad	....	2.80	(a)	(a)	(a)	(a)
9	....	Railroad	....	2.48	(a)	(a)	(a)	(a)
10	....	Railroad	....	2.74	(a)	(a)	(a)	(a)
11	11	Railroad	b.50	2.54	(a)	4.46	(a)	(a)
12	3	Railroad	.50	2.80	(a)	(a)	(a)	(a)
13	....	Railroad	....	2.49	(a)	4.50	(a)	(a)
14	....	Railroad	....	3.00	(a)	(a)	175	3.00
15	2	Railroad	(b)	1.38	(a)	(a)	79	1.38
16	1½	Railroad	(a)	(a)	(a)	(a)	(a)	(a)
17	2⅛	Railroad	1.40	1.50	(a)	6.00	2⅛	1.40
18	....	Railroad	....	1.40	(a)	(a)	(a)	(a)
19	½	Railroad	(b)	1.85	(a)	(a)	½	(b)
20	½	Railroad	(b)	1.35	(a)	4.25	(a)	(a)
21	¾	Railroad	(b)	(a)	(a)	(a)	(a)	(a)
22	9	Railroad	.50	(a)	(a)	(a)	9	.50
23	¼	Railroad	(b)	(a)	(a)	(a)	(a)	(a)
24	1	Railroad	(b)	2.42	(a)	(a)	155	2.42
25	....	Railroad	....	(a)	(a)	(a)	(a)	(a)
26	....	Railroad	....	2.50	(a)	5.00	127	2.50
27	....	Railroad	....	2.50	(a)	4.50	125	2.50
28	....	Railroad	....	2.50	(a)	5.00	125	2.50
29	....	Railroad	....	2.46	(a)	(a)	170	2.46
30	½	Railroad	(a)	(a)	(a)	(a)	(a)	(a)
31	....	Railroad	....	1.65	(a)	(a)	72	1.65
32	....	Railroad	....	(a)	(a)	(a)	(a)	(a)
33	10	Railroad	.50	2.50	(a)	(a)	185	3.00
34	....	Railroad	....	2.96	3.40	4.50	(a)	(a)
35	13	Railroad	(a)	(a)	(a)	(a)	(a)	(a)
36	....	Railroad	....	2.96	(a)	(a)	165	2.96
37	¾	Railroad	.50	(a)	(a)	(a)	¾	.50
38	....	Railroad	....	(a)	(a)	(a)	(a)	(a)
39	....	Railroad	....	2.91	(a)	(a)	155	2.91
40	....	Railroad	....	2.35	2.25	4.85	(a)	(a)
41	....	Railroad	....	2.49	(a)	(a)	(a)	(a)
42	....	Railroad	....	2.52	(a)	4.32	(a)	(a)
43	....	Railroad	....	2.40	(a)	4.60	(a)	7.00
44	5	Railroad	.50	(a)	(a)	(a)	5	.50
45	5	Railroad	(a)	(a)	(a)	(a)	(a)	(a)
46	4	Railroad	(a)	2.48	(a)	(a)	(a)	(a)
47	....	Railroad	....	2.50	(a)	4.50	(a)	(a)
48	....	Railroad	....	2.48	(a)	(a)	(a)	(a)
49	....	Railroad	....	1.85	(a)	5.25	(a)	(a)
50	....	Railroad	....	2.40	(a)	(a)	(a)	(a)
51	....	Railroad	....	(a)	(a)	(a)	(a)	(a)
52	....	Railroad	....	1.50	(a)	3.50	(a)	(a)
53	1¼	Railroad	(b)	(a)	(a)	(a)	(a)	(a)
54	....	Railroad	....	2.96	(a)	4.75	(a)	7.71
55	¼	Railroad	.40	(a)	(a)	(a)	¼	.40
56	....	Railroad	....	(a)	(a)	(a)	(a)	(a)
57	....	Railroad	....	(a)	(a)	(a)	(a)	(a)
58	....	Railroad	....	1.65	(a)	(a)	75	1.65
59	....	Railroad	....	(a)	(a)	(a)	(a)	(a)
60	½	Railroad	(b)	(a)	(a)	(a)	(a)	(a)
61	....	Railroad	....	1.70	(a)	(a)	(a)	(a)
62	....	Railroad	....	(a)	(a)	(a)	(a)	(a)
63	⅛	Railroad	.40	1.40	(a)	5.00	⅛	.40
64	1½	Railroad	(b)	1.50	(a)	5.00	1½	(b)
65	2	Railroad	(b)	(a)	(a)	(a)	2	(b)

a Not reported.
b Included in cost of wages, and supplies and repairs.

TABLE I.—COST OF PRODUCTION OF PHOSPHATE IN THE UNITED STATES, 1890-1892—LAND MINES—Continued.

C.—DISTANCE, MEANS, AND COST OF TRANSPORTATION—Concluded.

Establishment number.	Primary shipping point.		Cost of transportation per ton of 2,240 pounds.				Place of free delivery to purchaser.	
	Miles from mine.	On railroad or river.	From mine to railroad or river station.	From railroad or river station to port of shipment out of state.	From port of shipment out of state to—		Miles from mine.	Cost of transportation per ton of 2,240 pounds.
					Domestic selling port.	Foreign selling port.		
66		Railroad		(a)	(a)	(a)	(a)	(a)
67		Railroad		(a)	(a)	(a)	(a)	(a)
68	2½	Railroad	b $0.50	$2.50	$2.00	$4.80	(a)	(a)
69		Railroad		2.48	(a)	(a)	(a)	(a)
70	½	Railroad	(a)	(a)	(a)	(a)	(a)	(a)
71	½	Railroad	(b)	(a)	(a)	(a)	½	(b)
72		Railroad		(a)	(a)	(a)	(a)	(a)
73		Railroad		(a)	(a)	(a)	(a)	(a)
74	½	Railroad	(b)	(a)	(a)	(a)	½	(b)
75		Railroad		(a)	(a)	(a)	(a)	(a)
76		Railroad		(a)	(a)	(a)	(a)	(a)
77		Railroad		(a)	(a)	(a)	(a)	(a)
78		Railroad		(a)	(a)	(a)	(a)	(a)
79		Railroad		(a)	(a)	(a)	(a)	(a)
80		Railroad		(a)	(a)	(a)	(a)	(a)
81		Railroad		(a)	(a)	(a)	(a)	(a)
82		Railroad		2.69	(a)	(a)	(a)	(a)
83	4	Railroad	.15	(a)	(a)	(a)	4	$0.15
84		Railroad		.80	1.75	5.00	(a)	(a)
85		Railroad		1.35	(a)	(a)	(a)	(a)
86		Railroad		1.54	2.25	(a)	(a)	(a)
87		Railroad		1.15	2.25	4.50	(a)	(a)
88		Railroad		1.35	2.50	4.50	43	1.35
89	1	Railroad	b .10	(a)	(a)	(a)	1	b .10
90	(c)	River	b .10		1.80	4.00	(c)	b .10
91	(c)	River	b .20	.30	2.00	(a)	(c)	b .20
92	(c)	River	b .12	.40	2.25	4.55	(c)	b .12
93	(c)	Railroad	b .15	.50	2.00	5.00	(c)	b .15
94	(c)	River	b .10	.40	2.00	(a)	(c)	b .10
95	(d)	(d)	(d)	(d)	(d)	(d)	(d)	(d)
96	7	Both	b .27½	.42½	2.00	(a)	7	b .27½
97	(c)	River	b .10	.35	2.00	(a)	(c)	b .10
98	(c)	River	b .10	.40	2.00	(a)	(c)	b .10
99	d)	(d)	(d)	(d)	(d)	(d)	(d)	(d)
100	2	River	.19	.40	2.00	(a)	(a)	(a)
101	(c)	River	b .15	.50	2.00	(a)	(c)	b .15
102	(c)	River	b .08		(a)	5.00	(c)	b .08
103	(c)	River	b .15	.40	2.25	5.00	(c)	b .15
104	(c)	River	b .10	.40	2.00	4.75	(c)	b .10
105	(c)	River	b .20	.35	2.00	5.00	(c)	b .20
106	(c)	River	b .10	.40	2.00	(a)	20	.40
107	(c)	River	b .15	.75	2.00	(a)	(c)	b .15
108	(c)	River	b .10	.15	2.00	5.00	(c)	b .10
109	2½	River	b .10		2.12½	4.00	2½	b .10
110	4	River	b .10	40	2.00	(a)	4	b .10
111	(c)	River	b .09	.26	(a)	3.49	(c)	b .09
112	2	River	(b)	.40	2.00	(a)	18	.40

a Not reported.
b Included in cost of wages, and supplies and repairs.
c Contiguous.
d Manufactured on the premises.

TABLE I.—COST OF PRODUCTION OF PHOSPHATE IN THE UNITED STATES, 1890-1892—LAND MINES—Continued.

D.—GENERAL STATEMENT OF COST FOR THE PERIOD.

[Insurance, interest, depreciation of value of plant, charges for freight of product to place of free delivery, and royalty to owners of the soil are not included.]

Establishment number.	Labor.	Officials and clerks.	Supplies and repairs.	Taxes.	Total.
1	$400	$150	*a* $700	(*a*)	$1,250
2	1,875	(*b*)	433	....	2,308
3	2,000	535	762	$161	3,458
4	2,430	750	550	(*c*)	*d* 3,730
5	7,300	1,100	3,200	200	11,800
6	12,600	1,350	823	113	14,886
7	9,260	2,400	1,330	183	13,173
8	1,356	1,750	340	35	3,481
9	1,570	(*b*)	366	5	1,941
10	1,400	900	700	(*c*)	*d* 3,000
11	*e* 18,000	(*e*)	17,500	....	35,500
12	6,000	450	2,100	50	8,600
13	7,170	300	1,450	1,600	10,520
14	4,305	450	476	75	5,306
15	598	110	176	22	906
16	998	(*b*)	175	(*c*)	*d* 1,173
17	1,645	(*b*)	60	....	1,705
18	693	(*b*)	25	8	726
19	1,075	(*b*)	289	25	1,389
20	2,333	(*b*)	464	111	2,908
21	1,800	300	700	18	2,818
22	1,770	(*b*)	190	50	2,010
23	1,550	(*b*)	225	16	1,791
24	8,100	(*b*)	1,008	....	9,108
25	49,158	2,565	7,765	750	60,238
26	17,100	3,000	1,200	98	21,398
27	18,260	2,400	400	....	21,060
28	13,131	2,145	3,150	30	18,456
29	19,816	3,600	6,148	1,000	30,564
30	4,166	1,150	582	500	6,398
31	1,799	600	542	....	2,941
32	7,209	675	1,763	200	9,847
33	3,785	450	481	....	4,716
34	102,594	8,364	12,000	2,300	125,258
35	3,000	200	1,090	....	4,290
36	13,528	2,400	1,684	300	17,912
37	3,225	700	385	8	4,318
38	44,700	1,500	3,906	450	50,556
39	31,168	4,800	6,000	3,700	45,668
40	24,780	4,680	9,000	122	38,582
41	15,220	5,100	1,720	350	22,390
42	16,500	3,000	1,000	75	20,575
43	25,577	(*c*)	(*c*)	(*c*)	*f* 25,577
44	800	(*b*)	300	....	1,100
45	3,675	775	250	51	4,751
46	6,000	870	1,500	(*c*)	*d* 8,370
47	5,000	1,500	600	(*c*)	*d* 7,100
48	9,675	225	1,800	....	11,700
49	5,458	495	778	(*c*)	*d* 6,731
50	2,340	500	165	....	3,005
51	5,400	(*c*)	538	340	*g* 6,278
52	11,287	560	365	300	12,512
53	4,481	210	772	....	5,463
54	7,300	1,800	2,110	....	11,210
55	3,192	1,000	200	....	4,392
56	35,997	5,400	2,590	313	44,300
57	8,562	1,640	896	450	11,548
58	33,600	*h* 1,920	19,000	516	*h* 55,036
59	2,947	515	450	185	4,097
60	810	100	....	....	910
61	2,100	1,700	858	180	4,838
62	5,400	2,500	488	18	8,406
63	704	(*b*)	56	....	760
64	3,011	(*c*)	393	88	*g* 3,492
65	2,374	(*c*)	812	....	*g* 3,186

a The expenditures for taxes are inseparably combined with those for supplies and repairs.
b Managed by owner.
c Not reported.
d Not including taxes.
e The expenditures for officials and clerks are inseparably combined with those for labor.
f Not including officials and clerks, supplies and repairs, and taxes.
g Not including officials and clerks.
h Not including salary of general manager.

TABLE I.—COST OF PRODUCTION OF PHOSPHATE IN THE UNITED STATES, 1890-1892—LAND MINES—Continued.

D.—GENERAL STATEMENT OF COST FOR THE PERIOD—Concluded.

[Insurance, interest, depreciation of value of plant, charges for freight of product to place of free delivery, and royalty to owners of the soil are not included.]

Establishment number.	Labor.	Officials and clerks.	Supplies and repairs.	Taxes.	Total.
66	$919	$300	$95	....	$1,314
67	2,355	1,200	590	$250	4,395
68	3,000	(a)	416	229	3,645
69	1,250	(a)	800	....	2,050
70	1,110	150	190	8	1,458
71	1,048	(a)	361	....	1,409
72	2,018	(a)	362	....	2,380
73	455	(b)	81	(b)	c 536
74	1,770	(a)	550	....	2,320
75	5,880	600	875	44	7,399
76	824	(a)	359	....	1,183
77	435	(a)	203	....	638
78	569	150	134	75	928
79	2,136	400	1,159	....	3,695
80	1,870	900	308	....	3,078
81	5,450	3,000	1,710	20	10,180
82	6,205	3,000	2,340	150	11,695
83	1,088	750	185	10	2,033
84	5,865	3,456	5,212	117	14,650
85	2,204	3,417	1,639	492	7,752
86	5,049	3,100	515	13	8,677
87	4,200	1,350	1,020	150	6,720
88	10,800	5,000	4,550	200	20,550
89	1,215	390	500	125	2,230
90	86,400	3,600	8,840	765	99,605
91	17,460	1,200	985	45	19,690
92	22,899	2,100	6,800	1,150	32,949
93	73,515	3,200	12,000	593	89,308
94	27,480	2,100	5,992	232	35,804
95	37,900	2,100	2,100	410	42,510
96	54,615	2,000	4,806	92	61,513
97	22,095	3,416	2,273	313	28,097
98	26,505	2,400	6,110	69	35,084
99	55,493	2,750	11,950	1,155	71,348
100	8,549	1,550	2,290	103	12,492
101	42,700	2,300	11,040	228	56,268
102	14,350	3,450	4,388	91	22,279
103	71,600	2,200	6,850	1,350	82,000
104	35,965	2,550	8,511	1,038	48,064
105	78,048	1,950	8,950	831	89,779
106	35,200	1,200	5,975	350	42,725
107	37,940	3,000	9,500	195	50,635
108	193,450	10,550	48,438	4,032	256,470
109	35,580	1,750	9,440	744	47,514
110	20,796	1,600	7,575	210	30,181
111	96,951	3,100	14,265	567	114,883
112	d 144,000	(d)	(b)	(b)	e 144,000

a Managed by owner.
b Not reported.
c Not including officials and clerks, and taxes.
d The expenditures for officials and clerks are inseparably combined with those for labor.
e Not including supplies and repairs, and taxes.

TABLE I.—COST OF PRODUCTION OF PHOSPHATE IN THE UNITED STATES, 1890-1892—LAND MINES—Continued.

E.—ELEMENTS OF COST IN ONE TON OF 2,240 POUNDS.

[Insurance, interest, depreciation of value of plant, charges for freight of product to place of free delivery, and royalty to owners of the soil are not included.]

Establishment number.	Labor.	Officials and clerks.	Supplies and repairs.	Taxes.	Total.
1	$1.600	$0.600	*a* $2.800	(*a*)	$5.000
2	1.250	(*b*)	.289	....	1.539
3	4.000	1.070	1.524	$0.322	6.916
4	1.350	.417	.305	(*c*)	*d* 2.072
5	1.123	.169	.492	.031	1.815
6	3.150	.338	.206	.028	3.722
7	3.307	.857	.475	.066	4.705
8	1.937	2.500	.486	.050	4.973
9	1.427	(*b*)	.333	.005	1.765
10	1.647	1.059	.823	(*c*)	*d* 3.529
11	*e* 1.200	(*e*)	1.167	....	2.367
12	2.182	.164	.763	.018	3.127
13	1.195	.050	.242	.266	1.753
14	2.870	.300	.317	.050	3.537
15	2.151	.396	.633	.079	3.259
16	1.996	(*b*)	.350	(*c*)	*d* 2.346
17	2.742	(*b*)	.100	....	2.842
18	5.544	(*b*)	.200	.064	5.808
19	2.048	(*b*)	.550	.048	2.646
20	2.916	(*b*)	.580	.139	3.635
21	2.571	.429	1.000	.026	4.026
22	1.770	(*b*)	.190	.050	2.010
23	1.550	(*b*)	.225	.016	1.791
24	2.025	(*b*)	.252	....	2.277
25	3.871	.202	.611	.059	4.743
26	4.275	.750	.300	.025	5.350
27	2.435	.320	.053	....	2.808
28	1.459	.239	.350	.003	2.051
29	1.652	.300	.512	.083	2.547
30	2.083	.575	.291	.250	3.199
31	1.799	.600	.542	....	2.941
32	2.403	.225	.588	.066	3.282
33	1.992	.237	.253	....	2.482
34	2.700	.220	.316	.060	3.296
35	2.000	.133	.727	....	2.860
36	2.082	.369	.259	.046	2.756
37	2.688	.583	.321	.006	3.598
38	2.980	.100	.260	.030	3.370
39	3.463	.533	.667	.411	5.074
40	1.026	.194	.373	.005	1.598
41	1.903	.637	.215	.044	2.799
42	1.179	.214	.072	.005	1.470
43	1.705	(*c*)	(*c*)	(*c*)	*f* 1.705
44	1.067	(*b*)	.400	....	1.467
45	1.225	.259	.083	.017	1.584
46	2.609	.378	.652	(*c*)	*d* 3.639
47	2.000	.600	.240	(*c*)	*d* 2.840
48	1.290	.030	.240	....	1.560
49	1.365	.124	.194	(*c*)	*d* 1.683
50	2.600	.556	.183	....	3.339
51	1.800	(*c*)	.179	.114	*g* 2.093
52	1.567	.078	.051	.042	1.738
53	2.037	.095	.351	....	2.483
54	2.028	.500	.586	....	3.114
55	2.956	.926	.185	....	4.067
56	3.273	.491	.235	.028	4.027
57	3.568	.683	.373	.188	4.812
58	1.774	*h* .102	1.003	.027	*h* 2.906
59	3.929	.687	.600	.247	5.463
60	2.700	.333	....	....	3.033
61	1.050	.850	.429	.090	2.419
62	2.160	1.000	.195	.007	3.362
63	2.011	(*b*)	.160	....	2.171
64	3.764	(*c*)	.491	.110	*g* 4.365
65	1.826	(*c*)	.625	....	*g* 2.451

a The expenditures for taxes are inseparably combined with those for supplies and repairs.
b Managed by owner.
c Not reported.
d Not including taxes.
e The expenditures for officials and clerks are inseparably combined with those for labor.
f Not including officials and clerks, supplies and repairs, and taxes.
g Not including officials and clerks.
h Not including salary of general manager.

TABLE I.—COST OF PRODUCTION OF PHOSPHATE IN THE UNITED STATES, 1890–1892—LAND MINES—Continued.

E.—ELEMENTS OF COST IN ONE TON OF 2,240 POUNDS—Concluded.

[Insurance, interest, depreciation of value of plant, charges for freight of product to place of free delivery, and royalty to owners of the soil are not included.]

Establishment number.	Labor.	Officials and clerks.	Supplies and repairs.	Taxes.	Total.
66	$2.451	$0.800	$0.253		$3.504
67	1.178	.600	.295	$0.125	2.198
68	.817	(a)	.113	.062	.992
69	1.250	(a)	.800		2.050
70	2.220	.300	.330	.016	2.916
71	2.096	(a)	.722		2.818
72	1.495	(a)	.268		1.763
73	2.275	(b)	.405	(b)	[c] 2.680
74	2.950	(a)	.917		3.867
75	1.960	.200	.292	.014	2.466
76	1.030	(a)	.449		1.479
77	2.175	(a)	1.015		3.190
78	1.751	.461	.412	.231	2.855
79	3.560	.667	1.931		6.158
80	1.700	.818	.280		2.798
81	1.329	.732	.417	.005	2.483
82	1.241	.600	.468	.030	2.339
83	2.418	1.667	.411	.022	4.518
84	1.008	.594	.896	.020	2.518
85	.441	.683	.328	.098	1.550
86	1.683	1.033	.172	.004	2.892
87	1.400	.450	.340	.050	2.240
88	1.080	.500	.455	.020	2.055
89	1.736	.557	.714	.179	3.186
90	4.320	.180	.442	.038	4.980
91	3.492	.240	.197	.009	3.938
92	1.908	.175	.567	.096	2.746
93	2.940	.128	.480	.024	3.572
94	2.748	.210	.599	.023	3.580
95	3.877	.215	.215	.041	4.348
96	4.201	.154	.370	.007	4.732
97	3.399	.526	.350	.048	4.323
98	2.650	.240	.611	.007	3.508
99	2.643	.131	.569	.055	3.398
100	2.850	.517	.763	.034	4.164
101	2.372	.128	.613	.013	3.126
102	3.189	.767	.975	.020	4.951
103	3.580	.110	.343	.067	4.100
104	1.439	.102	.340	.042	1.923
105	3.252	.081	.373	.035	3.741
106	3.520	.120	.598	.035	4.273
107	2.108	.166	.528	.011	2.813
108	2.276	.124	.570	.047	3.017
109	2.737	.135	.726	.057	3.655
110	2.080	.160	.757	.021	3.018
111	3.366	.108	.495	.020	3.989
112	[d] 3.750	(d)	(b)	(b)	[e] 3.750

[a] Managed by owner.

[b] Not reported.

[c] Not including officials and clerks, and taxes.

[d] The expenditures for officials and clerks are inseparably combined with those for labor.

[e] Not including supplies and repairs, and taxes.

TABLE I.—COST OF PRODUCTION OF PHOSPHATE IN THE UNITED STATES, 1890-1892—LAND MINES—Continued.

F.—PER CENT. OF EACH ELEMENT OF COST IN ONE TON OF 2,240 POUNDS.

[Insurance, interest, depreciation of value of plant, charges for freight of product to place of free delivery, and royalty to owners of the soil are not included.]

Establishment number.	Labor.	Officials and clerks.	Supplies and repairs.	Taxes.	Total.
1	32.00	12.00	*a* 56.00	(*a*)	100
2	81.24	(*b*)	18.76	....	100
3	57.84	15.47	22.03	4.66	100
4	65.15	20.11	14.74	(*c*)	*d* 100
5	61.86	9.32	27.12	1.70	100
6	84.64	9.07	5.53	.76	100
7	70.29	18.22	10.10	1.39	100
8	38.95	50.27	9.77	1.01	100
9	80.88	(*b*)	18.86	.26	100
10	46.67	30.00	23.33	(*c*)	*d* 100
11	*e* 50.70	(*e*)	49.30	....	100
12	69.77	5.23	24.42	.58	100
13	68.16	2.85	13.78	15.21	100
14	81.14	8.48	8.97	1.41	100
15	66.00	12.14	19.43	2.43	100
16	85.08	(*b*)	14.92	(*c*)	*d* 100
17	96.48	(*b*)	3.52	....	100
18	95.46	(*b*)	3.44	1.10	100
19	77.39	(*b*)	20.81	1.80	100
20	80.23	(*b*)	15.95	3.82	100
21	63.87	10.65	24.84	.64	100
22	88.06	(*b*)	9.45	2.49	100
23	86.55	(*b*)	12.56	.89	100
24	88.93	(*b*)	11.07	....	100
25	81.61	4.26	12.89	1.24	100
26	79.91	14.02	5.61	.46	100
27	86.70	11.40	1.90	....	100
28	71.15	11.62	17.07	.16	100
29	64.83	11.78	20.12	3.27	100
30	65.11	17.97	9.10	7.82	100
31	61.17	20.40	18.43	....	100
32	73.21	6.86	17.90	2.03	100
33	80.26	9.54	10.20	....	100
34	81.90	6.68	9.58	1.84	100
35	69.93	4.66	25.41	....	100
36	75.52	13.40	9.40	1.68	100
37	74.69	16.21	8.92	.18	100
38	88.42	2.97	7.72	.89	100
39	68.25	10.51	13.14	8.10	100
40	64.23	12.13	23.33	.31	100
41	67.98	22.78	7.68	1.56	100
42	80.19	14.58	4.86	.37	100
43	100.00	(*c*)	(*c*)	(*c*)	*f* 100
44	72.73	*b*)	27.27	....	100
45	77.35	16.31	5.26	1.08	100
46	71.69	10.39	17.92	(*c*)	*d* 100
47	70.42	21.13	8.45	(*c*)	*d* 100
48	82.69	1.92	15.39	....	100
49	81.09	7.35	11.56	(*c*)	*d* 100
50	77.87	16.64	5.49	....	100
51	86.01	(*c*)	8.57	5.42	*g* 100
52	90.21	4.47	2.92	2.40	100
53	82.03	3.84	14.13	....	100
54	65.12	16.06	18.82	....	100
55	72.68	22.77	4.55	....	100
56	81.26	12.19	5.84	.71	100
57	74.14	14.20	7.76	3.90	100
58	61.05	*h* 3.49	34.52	.94	*h* 100
59	71.93	12.57	10.98	4.52	100
60	89.01	10.99	....	....	100
61	43.41	35.14	17.73	3.72	100
62	64.24	29.74	5.81	.21	100
63	92.63	(*b*)	7.37	....	100
64	86.23	(*c*)	11.25	2.52	*g* 100
65	74.51	(*c*)	25.49	....	*g* 100

a The expenditures for taxes are inseparably combined with those for supplies and repairs.
b Managed by owner.
c Not reported.
d Not including taxes.
e The expenditures for officials and clerks are inseparably combined with those for labor.
f Not including officials and clerks, supplies and repairs, and taxes.
g Not including officials and clerks.
h Not including salary of general manager.

TABLE I.—COST OF PRODUCTION OF PHOSPHATE IN THE UNITED STATES, 1890-1892—LAND MINES—Continued.

F.—PER CENT. OF EACH ELEMENT OF COST IN ONE TON OF 2,240 POUNDS—Concluded.

[Insurance, interest, depreciation of value of plant, charges for freight of product to place of free delivery, and royalty to owners of the soil are not included.]

Establishment number.	Labor.	Officials and clerks.	Supplies and repairs.	Taxes.	Total.
66	69.94	22.83	7.23	....	100
67	53.58	27.30	13.43	5.69	100
68	82.31	(a)	11.41	6.28	100
69	60.98	(a)	39.02	....	100
70	76.13	10.29	13.03	.55	100
71	74.38	(a)	25.62	....	100
72	84.79	(a)	15.21	....	100
73	84.89	(b)	15.11	(b)	c 100
74	76.29	(a)	23.71	....	100
75	79.47	8.11	11.83	.59	100
76	69.65	(a)	30.35	....	100
77	68.18	(a)	31.82	....	100
78	61.32	16.16	14.44	8.08	100
79	57.81	10.82	31.37	....	100
80	60.75	29.24	10.01	....	100
81	53.53	29.47	16.80	.20	100
82	53.06	25.65	20.01	1.28	100
83	53.52	36.89	9.10	.49	100
84	40.03	23.59	35.58	.80	100
85	28.43	44.08	21.14	6.35	100
86	58.19	35.73	5.93	.15	100
87	62.50	20.09	15.18	2.23	100
88	52.55	24.33	22.14	.98	100
89	54.48	17.49	22.42	5.61	100
90	86.74	3.61	8.88	.77	100
91	88.67	6.10	5.00	.23	100
92	69.50	6.37	20.64	3.49	100
93	82.32	3.58	13.44	.66	100
94	76.75	5.86	16.74	.65	100
95	89.16	4.94	4.94	.96	100
96	88.79	3.25	7.81	.15	100
97	78.64	12.16	8.09	1.11	100
98	75.55	6.84	17.41	.20	100
99	77.78	3.85	16.75	1.62	100
100	68.44	12.41	18.33	.82	100
101	75.89	4.09	19.62	.40	100
102	64.41	15.48	19.70	.41	100
103	87.32	2.68	8.35	1.65	100
104	74.83	5.30	17.71	2.16	100
105	86.93	2.17	9.97	.93	100
106	82.39	2.81	13.98	.82	100
107	74.93	5.92	18.76	.39	100
108	75.43	4.11	18.89	1.57	100
109	74.88	3.68	19.87	1.57	100
110	68.90	5.30	25.10	.70	100
111	84.39	2.70	12.42	.49	100
112	d 100.00	(d)	(b)	(b)	e 100

a Managed by owner.
b Not reported.
c Not including officials and clerks, and taxes.
d The expenditures for officials and clerks are inseparably combined with those for labor.
e Not including supplies and repairs, and taxes.

TABLE I.—COST OF PRODUCTION OF PHOSPHATE IN THE UNITED STATES, 1890-1892—LAND MINES—Continued.

G.—ADDITIONAL COST OF CERTAIN THEORETICAL ELEMENTS FOR THE PERIOD.

Establishment number.	Insurance.	Interest.	Depreciation of value of plant.	Royalty to owners of the soil.	Transportation to place of free delivery.	Total.
1						
2					$700	$700
3	$80					80
4						
5	145				13,000	13,145
6						
7						
8						
9						
10	(*a*)	(*a*)	(*a*)			(*a*)
11	500	$3,000	$1,250		95,000	99,750
12				$1,375		1,375
13						
14					4,500	4,500
15					328	328
16						
17					770	770
18						
19						
20						
21						
22					250	250
23						
24				4,000	7,260	11,260
25						
26	219	(*a*)			8,663	*b* 8,882
27		(*a*)	70		18,750	*b* 18,820
28	250	3,000			22,500	25,750
29					22,500	22,500
30						
31					1,485	1,485
32						
33				1,900	2,949	4,849
34	775	4,126	5,400		230,000	240,301
35						
36					19,240	19,240
37					600	600
38	150	(*a*)				*b* 150
39	500				26,190	26,690
40	1,030				108,160	109,190
41	225					225
42		500				500
43	900			(*a*)	31,200	*c* 32,100
44					225	225
45						
46	(*a*)	(*a*)	(*a*)			(*a*)
47	(*a*)	(*a*)	(*a*)			(*a*)
48				7,500		7,500
49						
50						
51	45					45
52						
53				2,200		2,200
54					12,336	12,336
55				1,080	312	1,392
56	(*a*)	(*a*)	600			*d* 600
57	90					90
58	(*a*)	(*a*)	500		24,653	*d* 25,153
59	500					500
60						
61	450	1,000				1,450
62	65					65
63					80	80
64			50			50
65						
66						
67						
68					3,300	3,300
69						
70						

a Not reported.
b Not including interest.
c Not including royalty to owners of the soil.
d Not including insurance and interest.

TABLE I.—COST OF PRODUCTION OF PHOSPHATE IN THE UNITED STATES, 1890–1892—LAND MINES—Continued.

G.—ADDITIONAL COST OF CERTAIN THEORETICAL ELEMENTS FOR THE PERIOD—Concluded.

Establishment number.	Insurance.	Interest.	Depreciation of value of plant.	Royalty to owners of the soil.	Transportation to place of free delivery.	Total.
71				$500		$500
72						
73						
74				600		600
75						
76						
77						
78						
79						
80	$320					320
81	450					450
82	225					225
83				135	$15	150
84	1,450				14,831	16,281
85	270	$13				283
86	(a)	(a)				(a)
87	125					125
88	438				13,500	13,938
89						
90	95		$4,000			4,095
91	48	700	800			1,548
92			7,500			7,500
93	425		5,000			5,425
94	69		3,000			3,069
95	74		1,500			1,574
96			1,800	13,000		14,800
97	388	790	3,750			4,928
98	58		1,400	2,500		3,958
99	312		5,500			5,812
100			2,300	1,050	1,200	4,550
101	195		4,500	7,200		11,895
102	68		1,250			1,318
103			6,000			6,000
104			3,500			3,500
105	325		3,750			4,075
106	79		3,000		2,800	5,879
107	108		5,200			5,308
108	2,000		35,000			37,000
109	102		4,000			4,102
110	70		3,500			3,570
111	504		8,290	10,080	150,000	168,874
112	(a)	(a)	(a)		14,000	[b] 14,000

[a] Not reported.

[b] Not including insurance, interest, and depreciation of value of plant.

TABLE I.—COST OF PRODUCTION OF PHOSPHATE IN THE UNITED STATES, 1890-1892—LAND MINES—Continued.

II.—ADDITIONAL COST OF CERTAIN THEORETICAL ELEMENTS IN ONE TON OF 2,240 POUNDS.

Establishment number.	Insurance.	Interest.	Depreciation of value of plant.	Royalty to owners of the soil.	Transportation to place of free delivery.	Total.
1						
2					$0.500	$0.500
3	$0.160					.160
4						
5	.022				2.000	2.022
6						
7						
8						
9						
10	(a)	(a)	(a)			(a)
11	.033	$0.200	$0.083		6.786	7.102
12				$0.500		.500
13						
14					3.000	3.000
15					1.378	1.378
16						
17					1.400	1.400
18						
19						
20						
21						
22					.500	.500
23						
24				1.000	2.420	3.420
25						
26	.055	(a)			2.500	b 2.555
27		(a)	.009		2.500	b 2.509
28	.028	.333			2.500	2.861
29					2.045	2.045
30						
31					1.650	1.650
32						
33				1.000	3.000	4.000
34	.020	.109	.142		6.601	6.872
35						
36					2.960	2.960
37					.500	.500
38	.010	(a)				b .010
39	.056				2.910	2.966
40	.043				5.636	5.679
41	.028					.028
42		.036				.036
43	.060			(a)	7.000	c 7.060
44					.500	.500
45						
46	(a)	(a)	(a)			(a)
47	(a)	(a)	(a)			(a)
48				1.000		1.000
49						
50						
51	.015					.015
52						
53				1.000		1.000
54					7.710	7.710
55				1.000	.400	1.400
56	(a)	(a)	.055			d .055
57	.038					.038
58	(a)	(a)	.026		1.650	d 1.676
59	.667					.667
60						
61	.225	.500				.725
62	.026					.026
63					.400	.400
64			.063			.063
65						
66						
67						
68					1.257	1.257
69						
70						

a Not reported.
b Not including interest.
c Not including royalty to owners of the soil.
d Not including insurance and interest.

TABLE I.—COST OF PRODUCTION OF PHOSPHATE IN THE UNITED STATES, 1890-1892—LAND MINES—Continued.

II.—ADDITIONAL COST OF CERTAIN THEORETICAL ELEMENTS IN ONE TON OF 2,240 POUNDS—Concluded.

Establishment number.	Insurance.	Interest.	Depreciation of value of plant.	Royalty to owners of the soil.	Transportation to place of free delivery.	Total.
71				$1.000		$1.000
72						
73						
74				1.000		1.000
75						
76						
77						
78						
79						
80	$0.291					.291
81	.110					.110
82	.045					.045
83				.300	$0.150	.450
84	.249				2.550	2.799
85	.054	$0.003				.057
86	(a)	(a)				(a)
87	.042					.042
88	.044				1.350	1.394
89						
90	.005		$0.200			.205
91	.010	.140	.160			.310
92			.625			.625
93	.017		.200			.217
94	.007		.300			.307
95	.008		.153			.161
96			.138	1.000		1.138
97	.060	.121	.577			.758
98	.006		.140	.250		.396
99	.015		.262			.277
100			.767	.350	.400	1.517
101	.011		.250	.400		.661
102	.015		.278			.293
103			.300			.300
104			.140			.140
105	.014		.156			.170
106	.008		.300		.400	.708
107	.006		.289			.295
108	.023		.412			.435
109	.008		.308			.316
110	.007		.350			.357
111	.017		.288	.350	3.750	4.405
112	(a)	(a)	(a)		.400	b .400

a Not reported.

b Not including insurance, interest, and depreciation of value of plant.

TABLE I.—COST OF PRODUCTION OF PHOSPHATE IN THE UNITED STATES, 1890-1892—LAND MINES—Continued.

J.—RATES OF WAGES.

Establishment number.	Occupation.	Hours per day.	Average employés for period.	Daily rate of pay or average daily earnings.
1	Miners	*a* 10	12	$1.00
	Total	10	12	1.00
2	Engineer	10	1	3.00
	Fireman	10	1	1.50
	Miners	10	12	1.00
	Total	10	14	1.18
3	Engineer	10	1	2.50
	Fireman	10	1	1.50
	Miners	10	12	1.00
	Total	10	14	1.14½
4	Foreman	10	1	1.50
	Miners	10	12	1.00
	Total	10	13	1.04
5	Engineer	10	1	4.00
	Foreman	10	1	2.50
	Miners	10	30	1.00
	Total	10	32	1.14
6	Foremen	10	2	1.50
	Miners	10	60	1.00
	Total	10	62	1.01½
7	Blacksmiths	10	2	1.50
	Carpenters	10	2	2.00
	Engineer	10	1	2.50
	Fireman	10	1	1.50
	Foremen	10	5	1.50
	Miners	10	100	1.00
	Total	10	111	1.07
8	Carpenter	10	1	2.25
	Foreman	10	1	1.50
	Miners	10	5	1.00
	Total	10	7	1.25
9	Foreman	10	1	1.91½
	Miners	*a* 10	12	1.00
	Total	10	13	1.07
10	Foremen	10	5	2.30
	Miners	*a* 10	20	1.00
	Total	10	25	1.26
11	Foremen	10	3	1.91½
	Miners	10	50	1.00
	Total	10	53	1.05
12	Engineer	10	1	2.00
	Foremen	10	2	2.39½
	Miners	*a* 10	30	1.00
	Total	10	33	1.11½
13	Engineer	10	1	1.53½
	Foremen	10	2	3.26
	Machinist	10	1	2.87½
	Miners	*a* 10	35	1.00
	Total	10	39	1.18
14	Foremen	10	2	$1.34
	Miners and laborers	10	25	1.25
	Teamsters	10	3	1.25
	Total	10	30	1.25½
15	Miners and laborers	10	5	1.10
	Teamsters	10	2	1.10
	Total	10	7	1.10
16	Foreman	10	1	2.49
	Miners and laborers	10	20	1.25
	Total	10	21	1.31
17	Foreman	*b* 10	1	1.84½
	Miners and laborers	*b* 10	6	1.25
	Total	10	7	1.33½
18	Foreman	10	1	1.50
	Miners and laborers	10	12	1.25
	Total	10	13	1.27
19	Blaster	*a* 10	1	1.25
	Foreman	10	1	1.25
	Miners and laborers	*a* 10	19	1.00
	Total	10	21	1.02½
20	Engineer	10	1	1.50
	Foreman	10	1	1.53½
	Miners and laborers	10	18	1.00
	Teamster	10	1	1.00
	Total	10	21	1.05
21	Foreman	10	1	2.30
	Miners and laborers	10	20	1.25
	Total	10	21	1.30
22	Foreman	10	1	1.91½
	Miners	10	12	1.00
	Water boy	10	1	.50
	Total	10	14	1.03
23	Miners and laborers	10	12	1.20
	Teamsters	10	2	.87½
	Total	10	14	1.15½
24	Foremen	10	3	1.91½
	Miners and laborers	10	30	1.00
	Teamsters	10	2	1.00
	Water boy	10	1	.50
	Total	10	36	1.06
25	Engineer	10	1	4.79
	Foremen	10	4	1.75
	Miners and laborers	10	150	1.25
	Teamsters	10	5	1.25
	Water boys	10	6	.75
	Total	10	166	1.26½
26	Engineers	10	4	1.31½
	Foremen	10	4	1.92
	Laborers	10	10	1.00
	Miners	10	50	1.00
	Total	10	68	1.07½

a Work 5½ days per week.
b Work 5 days per week.

TABLE I.—COST OF PRODUCTION OF PHOSPHATE IN THE UNITED STATES, 1890–1892—LAND MINES—Continued.

J.—RATES OF WAGES—Continued.

Establishment number.	Occupation.	Hours per day.	Average employés for period.	Daily rate of pay or average daily earnings.
27	Foremen	10	2	$3.00
	Laborers	10	10	1.00
	Miners	10	50	1.00
	Total	10	62	1.06½
28	Engineer	10	1	1.75
	Foremen	10	3	2.00
	Miners and laborers	10	40	1.00
	Total	10	44	1.08½
29	Engineer	10	1	1.91½
	Foremen	10	3	1.91½
	Miners and laborers	10	75	1.00
	Teamsters	10	6	1.00
	Watchman	10	1	.98½
	Water boys	10	2	.50
	Total	10	88	1.03
30	Foremen	10	2	1.91½
	Mechanic	10	1	1.50
	Miners and laborers	10	30	1.00
	Teamsters	10	3	1.00
	Water boy	10	1	.50
	Total	10	37	1.05
31	Foreman	10	1	1.91½
	Miners and laborers	10	12	1.25
	Teamsters	10	4	1.25
	Water boy	10	1	.50
	Total	10	18	1.24½
32	Foreman	10	1	2.30
	Miners and laborers	10	25	1.00
	Teamsters	10	2	1.00
	Water boys	10	2	.75
	Total	10	30	1.02½
33	Foremen	9⅙	2	2.20½
	Miners and laborers	9⅙	17	1.10
	Teamsters	9⅙	2	1.10
	Water boy	9⅙	1	.50
	Total	9⅙	22	1.17½
34	Blacksmiths	11	2	1.91½
	Carpenters	11	8	1.91½
	Engineers	11	8	2.30
	Foremen	11	6	2.30
	Machinists	11	2	3.83½
	Miners and laborers	11	275	1.00
	Teamsters	11	4	1.00
	Watchmen	11	2	1.00
	Total	11	307	1.11
35	Miners and laborers	10	102	1.00
	Total	10	102	1.00
36	Engineer	10	1	1.75
	Foreman	10	1	2.00
	Miners and laborers	10	50	1.00
	Teamster	10	1	1.00
	Watchman	10	1	1.00
	Water boys	10	2	.75
	Total	10	56	1.02

Establishment number.	Occupation.	Hours per day.	Average employés for period.	Daily rate of pay or average daily earnings.
37	Miners and laborers	10	16	$1.25
	Teamster	10	1	1.00
	Water boy	10	1	.50
	Total	10	18	1.19½
38	Foremen	11	15	1.53½
	Miners and laborers	11	125	1.00
	Total	11	140	1.05½
39	Blacksmith	10	1	2.30
	Carpenter	10	1	2.87½
	Engineers	10	3	1.00
	Foremen	10	5	1.91½
	Miners and laborers	10	70	1.00
	Stableman	(a)	1	1.00
	Teamsters	10	20	1.00
	Watchman	(a)	1	.98½
	Water boys	10	4	.75
	Total	......	106	1.06½
40	Blacksmith	10	1	2.00
	Carpenter	10	1	3.00
	Engineers	10	2	1.75
	Engineer, locomotive.	10	1	1.15
	Firemen	10	2	1.25
	Laborers	10	13	1.25
	Machinists	10	3	2.66½
	Miners	10	42	1.00
	Teamsters	10	2	1.15
	Watchman	10	1	1.48
	Total	10	68	1.21
41	Engineers	10	2	1.91½
	Firemen	10	2	1.24½
	Foremen	10	2	1.91½
	Miners and laborers	10	56	1.00
	Watchmen	10	2	.98½
	Water boys	10	2	.50
	Total	10	66	1.04½
42	(b)	(b)	(b)	(b)
43	Blacksmith	10	1	1.75
	Carpenters	10	4	1.75
	Foremen	10	6	1.50
	Machinists	10	4	1.50
	Miners	10	60	1.00
	Stableman	10	1	1.00
	Teamsters	10	17	1.00
	Total	10	93	1.09½
44	Blacksmith	10	1	1.50
	Engineer	10	1	1.72½
	Fireman	10	1	1.00
	Foreman	10	1	1.50
	Miners and laborers	c 10	20	1.00
	Total	10	24	1.07
45	Foremen	d 10	2	2.10
	Miners	d 10	15	1.00
	Total	10	17	1.13
46	Miners	d 10	50	1.00
	Total	10	50	1.00

a Variable.
b Not reported.
c Work 5¾ days per week.
d Work 5½ days per week.

TABLE I.—COST OF PRODUCTION OF PHOSPHATE IN THE UNITED STATES, 1890-1892—LAND MINES—Continued.

J.—RATES OF WAGES—Continued.

Establishment number.	Occupation.	Hours per day.	Average employés for period.	Daily rate of pay or average daily earnings.
47	Engineer	10	1	$2.49
	Miners	*a* 10	20	1.00
	Total	10	21	1.07
48	Blacksmith	10	1	2.00
	Carpenters	10	2	2.00
	Engineer	10	1	2.50
	Foremen	10	3	2.00
	Miners	*a* 10	50	1.00
	Total	10	57	1.13
49	Carpenter	10	1	1.91½
	Engineer	10	1	1.53½
	Fireman	10	1	1.25
	Miners and laborers	10	20	1.10
	Teamster	10	1	1.25
	Total	10	24	1.16½
50	Miners and laborers	10	18	1.00
	Total	10	18	1.00
51	Foremen	10	2	2.30
	Miners and laborers	10	40	1.10
	Teamster	10	1	1.00
	Total	10	43	1.15½
52	Engineer	10	1	2.00
	Foremen	10	3	1.53½
	Miners and laborers	10	50	1.10
	Teamsters	10	5	1.00
	Water boys	10	2	.60
	Total	10	61	1.11
53	Foremen	*a* 10	3	1.75
	Mechanic	*a* 10	1	1.75
	Miners and laborers	*a* 10	50	1.00
	Teamsters	*a* 10	5	1.05
	Water boys	*a* 10	2	.50
	Total	10	61	1.03½
54	Blacksmith	10	1	2.00
	Foreman	10	1	1.91½
	Miners and laborers	10	25	1.00
	Teamsters	10	6	1.00
	Water boy	10	1	.50
	Total	10	34	1.04
55	Foreman	*a* 10	1	1.63½
	Miners and laborers	*a* 10	12	1.25
	Total	10	13	1.28
56	Engineer	10	1	2.00
	Engineers, assistant	10	2	1.50
	Foremen	10	6	1.98
	Mechanics	10	2	2.00
	Miners and laborers	10	110	1.00
	Stableman	10	1	1.64½
	Teamsters	10	4	1.25
	Watchmen	10	2	1.25
	Water boys	10	3	.65
	Total	10	131	1.08½
57	Foremen	10	3	$1.91½
	Miners and laborers	10	100	1.00
	Teamsters	10	2	1.00
	Water boys	10	4	.50
	Total	10	109	1.00½
58	Foremen	10	5	2.30
	Miners and laborers	10	100	1.00
	Total	10	105	1.06
59	Blacksmith	10	1	2.00
	Carpenter	10	1	2.00
	Engineers	10	5	1.33½
	Foremen	10	4	2.30
	Miners and laborers	10	50	1.00
	Stableman	10	1	1.00
	Teamsters	10	7	1.10
	Watchman	10	1	1.00
	Water boys	10	3	.50
	Total	10	73	1.11
60	Laborers	10	3	1.00
	Miners	10	12	1.00
	Total	10	15	1.00
61	Engineer	10	1	2.87½
	Fireman	10	1	1.53½
	Mill hands	10	2	1.53½
	Miners	10	3	1.00
	Teamsters	10	3	1.00
	Total	10	10	1.35
62	Engineer	10	1	3.87½
	Miners and laborers	10	15	1.00
	Total	10	16	1.18
63	Foreman	*a* 10	1	1.52½
	Miners and laborers	*a* 10	6	1.25
	Total	10	7	1.29
64	Engineer	10	1	1.25
	Foreman	10	1	2.50
	Miners and laborers	10	12	1.25
	Water boy	10	1	.75
	Total	10	15	1.30
65	Engineer	10	1	1.00
	Foremen	10	2	2.06½
	Miners and laborers	10	10	1.00
	Teamsters	10	4	1.00
	Water boys	10	2	.40
	Total	10	19	1.05
66	Foreman	10	1	2.30
	Miners and laborers	10	10	1.25
	Teamster	10	1	1.25
	Water boy	10	1	.50
	Total	10	13	1.27½
67	Foreman	*a* 10	1	1.26
	Miners and laborers	*a* 10	7	1.00
	Total	10	8	1.03½

a Work 5½ days per week.

TABLE I.—COST OF PRODUCTION OF PHOSPHATE IN THE UNITED STATES, 1890-1892—LAND MINES—Continued.

J.—RATES OF WAGES—Continued.

Establishment number.	Occupation.	Hours per day.	Average employés for period.	Daily rate of pay or average daily earnings.
68	Foremen	10	2	$1.50
	Miners	10	12	1.00
	Total	10	14	1.07
69	Miners	a 10	10	1.00
	Total	10	10	1.00
70	Foreman	10	1	1.53½
	Miners and laborers	10	20	1.25
	Total	10	21	1.26½
71	Fireman	10	1	1.00
	Foreman	10	1	1.91½
	Miners and laborers	10	12	1.00
	Teamster	10	1	1.00
	Watchman	10	1	1.00
	Total	10	16	1.05½
72	Engineer	10	1	2.87½
	Foreman	10	1	1.91½
	Miners and laborers	10	12	1.00
	Teamster	10	1	1.00
	Total	10	15	1.18½
73	Fireman	10	1	1.25
	Foremen	10	2	2.00
	Miners and laborers	10	7	1.00
	Total	10	10	1.22½
74	Engineer	10	1	1.00
	Foreman	10	1	1.72½
	Miners and laborers	10	12	1.00
	Total	10	14	1.05
75	Carpenter	10	1	1.53½
	Engineer	10	1	1.91½
	Foremen	10	2	1.91½
	Miners and laborers	a 10	25	1.00
	Teamster	a 10	1	1.00
	Total	10	30	1.11
76	Engineer	10	1	1.25
	Engineer, assistant	10	1	1.00
	Foreman	10	1	2.49
	Miners and laborers	10	13	1.00
	Teamster	10	1	1.00
	Watchman	10	1	1.00
	Total	10	18	1.09½
77	Engineers	10	2	1.62½
	Foreman	10	1	2.49
	Miners and laborers	10	13	1.00
	Watchman	10	1	1.00
	Total	10	17	1.16
78	Engineer	10	1	1.53½
	Foreman	10	1	1.53½
	Miners and laborers	10	10	1.00
	Teamster	10	1	1.00
	Water boy	10	1	.50
	Total	10	14	1.04
79	Engineer	10	1	$1.50
	Engineers, assistant	10	2	1.00
	Foreman	10	1	2.87½
	Miners and laborers	10	20	1.00
	Water boys	10	2	.50
	Total	10	26	1.05½
80	Engineer	9	1	2.80
	Engineers, assistant	9	4	1.16
	Foreman	9	1	2.30
	Miners and laborers	9	18	.90
	Teamster	9	1	1.00
	Watchman	(b)	1	1.00
	Total	......	26	1.05½
81	Engineer	10	1	1.49½
	Engineers, assistant	10	5	1.25
	Foremen	10	2	2.87½
	Miners and laborers	10	32	1.00
	Teamster	10	1	1.00
	Water boys	10	3	.50
	Total	10	44	1.09
82	Engineer	10	1	2.30
	Fireman	10	1	1.53½
	Foreman	10	1	2.87½
	Miners and laborers	10	25	1.00
	Watchman	10	1	1.31½
	Total	10	29	1.14
83	Engineer	10	1	1.75
	Fireman	10	1	1.00
	Foreman	10	1	1.50
	Miners	10	3	1.00
	Total	10	6	1.21
84	Dredgemen	10	3	1.25
	Engineers	10	2	2.50
	Engineer, locomotive.	10	1	1.50
	Foremen	10	2	1.35
	Miners and laborers	10	6	1.25
	Washers	10	9	1.25
	Watchman	10	1	.98½
	Total	10	24	1.36
85	Captain, dredge	10	1	3.83½
	Engineer	10	1	1.91½
	Firemen	10	3	1.25
	Miners and laborers	10	8	1.25
	Watchmen	10	2	1.50
	Total	10	15	1.50
86	Engineer	10	1	2.16
	Firemen	10	2	1.50
	Foreman	10	1	2.00
	Miners and laborers	10	20	1.25
	Winchman	10	1	1.50
	Total	10	25	1.34½
87	Engineers	10	2	2.30
	Firemen	10	2	1.34
	Miners and laborers	10	19	1.00
	Watchman	10	1	1.15
	Total	10	24	1.14½

a Work 5½ days per week.
b Not reported.

TABLE I.—COST OF PRODUCTION OF PHOSPHATE IN THE UNITED STATES, 1890-1892—LAND MINES—Continued.

J.—RATES OF WAGES—Continued.

Establishment number.	Occupation.	Hours per day.	Average employés for period.	Daily rate of pay or average daily earnings.
88	Carpenters	11	2	$1.91½
	Engineers	11	3	2.30
	Firemen	11	3	1.53½
	Foremen	11	2	2.11
	Miners and laborers	11	22	1.37½
	Watchman	11	1	1.31½
	Total	11	33	1.55
89	Miners and laborers	10	18	.75
	Total	10	18	.75
90	Blacksmith	10	1	1.50
	Dumpers	10	4	1.00
	Engineer	10	1	3.06½
	Engineers, locomotive.	10	2	1.72½
	Firemen	10	3	.97½
	Foreman	10	1	3.45
	Laborers, railroad	10	5	1.00
	Miners and laborers	10	250	1.04½
	Total	10	267	1.06½
91	Dumpers	10	2	1.00
	Engineer	10	1	1.50
	Fireman	10	1	.83½
	Miners and laborers	10	53	1.00
	Total	10	57	1.00½
92	Blacksmith	10	1	1.50
	Carpenter	10	1	1.60
	Dumpers	10	2	1.00
	Engineer	10	1	1.50
	Engineer, excavator	10	1	2.39½
	Fireman	10	1	1.10
	Miners	10	75	.88½
	Total	10	82	.93½
93	Carpenter	10	1	1.50
	Dumpers	10	3	1.00
	Engineer	10	1	2.49
	Engineers, locomotive.	10	2	2.39½
	Firemen	10	3	1.25
	Miners and laborers	10	200	1.16
	Total	10	210	1.18
94	Engineers	10	2	3.06½
	Firemen	10	2	1.00
	Foremen	10	2	1.53½
	Miners and laborers	10	75	1.06½
	Total	10	81	1.12½
95	Carpenter	10	1	1.50
	Dumpers	10	2	1.00
	Engineers	10	2	2.25
	Laborers, railroad	10	3	1.00
	Machinist	10	1	3.33½
	Miners and laborers	10	176	.97½
	Total	10	185	1.00½
96	Engineer, locomotive.	10	1	1.50
	Fireman	10	1	1.00
	Miners and laborers	(a)	300	1.18½
	Trackmen	10	6	1.00
	Total	......	308	1.18
97	Blacksmith	10	1	$1.25
	Dumpers	10	3	1.25
	Engineer	10	1	1.50
	Fireman	10	1	1.00
	Miners	10	70	1.00
	Total	10	76	1.02
98	Blacksmith	10	1	1.50
	Dumpers	10	2	1.00
	Engineer	(a)	1	2.87½
	Engineer, locomotive.	(a)	1	2.30
	Firemen	10	2	1.25
	Miners and laborers	10	130	1.00
	Trackmen	10	2	1.00
	Total	......	139	1.03
99	Blacksmith	10	1	1.75
	Engineer	(a)	1	2.49
	Engineer, locomotive.	(a)	1	1.45½
	Fireman	(a)	1	.92
	Miners	10	240	1.00
	Total	......	244	1.01
100	Blacksmith	10	1	1.25
	Dumper	10	1	1.00
	Engineer	10	1	1.50
	Fireman	10	1	1.10
	Miners and laborers	(a)	50	.68½
	Sorters	10	2	1.00
	Total	......	56	.73½
101	Blacksmith	10	1	1.50
	Dumpers	10	3	1.00
	Engineer	10	1	1.50
	Fireman	10	1	1.25
	Machinist	10	1	1.75
	Miners and laborers	10	150	.81
	Total	10	157	.83
102	Dumper	10	1	1.00
	Engineer	10	1	2.50
	Engineer, locomotive.	10	1	1.50
	Fireman	10	1	1.00
	Laborers, railroad	10	2	1.00
	Miners	10	41	1.00
	Total	10	47	1.04½
103	Blacksmith	10	1	1.50
	Carpenter	10	1	1.75
	Dumpers	10	2	1.00
	Engineer	10	1	1.50
	Fireman	10	1	1.25
	Miners	10	231	1.00
	Total	10	237	1.01
104	Dumpers	10	3	1.00
	Engineer	(a)	1	3.19½
	Engineers, locomotive.	10	2	2.30
	Firemen	10	3	1.25
	Foreman	10	1	1.25
	Miners and laborers	10	105	1.00
	Trackmen	10	3	1.00
	Total	......	118	1.05

a Variable.

TABLE I.—COST OF PRODUCTION OF PHOSPHATE IN THE UNITED STATES, 1890-1892—LAND MINES—Concluded.

J.—RATES OF WAGES—Concluded.

Establishment number.	Occupation.	Hours per day.	Average employés for period.	Daily rate of pay or average daily earnings.
105	Dumpers	10	5	$1.00
	Engineer	10	1	1.66½
	Engineer, locomotive.	10	1	1.66½
	Firemen	10	2	1.00
	Foreman	(a)	1	2.87½
	Miners and laborers	(a)	250	.97
	Trackmen	10	5	.90
	Total	......	265	.98
106	Blacksmith	10	1	1.25
	Dumpers	10	6	1.00
	Engineer	10	1	2.23½
	Fireman	10	1	1.25
	Miners	10	127	.83½
	Total	10	136	.86
107	Blacksmith	10	1	1.50
	Carpenter	10	1	1.50
	Engineer	(a)	1	3.45
	Engineers, locomotive.	(a)	2	2.01½
	Firemen	10	3	1.25
	Miners and laborers	10	112	1.00
	Total	......	120	1.05
108	Carpenters	10	6	1.75
	Engineer	10	1	1.59½
	Engineers, locomotive.	10	6	1.50
	Firemen	10	6	1.50
	Foremen	10	9	2.91
	Laborers, railroad	10	14	1.00
	Miners and laborers	10	573	1.00
	Total	10	615	1.04½
109	Blacksmith	10	1	$1.50
	Carpenters	10	2	1.41½
	Chief engineer and mechanic.	10	1	4.16½
	Engineer	10	1	1.50
	Engineer, locomotive.	10	1	1.66½
	Foreman	10	1	4.16½
	Miners	10	108	1.00
	Trackmen	10	4	1.00
	Total	10	119	1.07½
110	Dumpers	10	2	1.00
	Engineers	10	3	1.91½
	Firemen	10	2	1.25
	Miners and laborers	10	74	1.09
	Total	10	81	1.12
111	Dipper tender	10	1	2.00
	Engineers	10	3	2.97½
	Engineer, locomotive.	10	1	2.30
	Firemen	10	3	1.12½
	Miners and laborers	10	300	1.00
	Trackmen	10	6	1.00
	Total	10	314	1.02½
112	Laborers (b)	10	400	1.00
	Total	10	400	1.00

a Variable.
b Skilled labor is not reported.

TABLE II.—COST OF PRODUCTION OF PHOSPHATE IN THE UNITED STATES, 1890-1892—RIVER MINES.

A.—PERIOD COVERED AND QUANTITY OF PRODUCT.

Establishment number.	Locality.	Period covered.		Phosphate mined.				Quantity shipped (tons of 2,240 pounds).
		Year ending—	Days of running time.	Description.	Per cent. of bone phosphate.	Quantity (tons of 2.240 pounds).	Value at mine.	
1	Florida	Nov. 30, 1892	210	River pebble	66.95	5,218	$17,200	5.218
2	....do	Dec. 1, 1892	150	River pebble	60.00	8,000	48,000	8,000
3	....do	Dec. 31, 1891	270	River pebble	(*a*)	12,000	60,000	10,000
4	....do	Sept. 1, 1892	130	River pebble	59.24	4,641	17,680	4,641
5	....do	Dec. 1, 1892	140	River pebble	69.22	6,330	22,155	4,888
6	....do	Nov. 30, 1892	150	River pebble	60.71	7,500	30,000	5,500
7	....do	Dec. 31, 1892	135	River pebble	62.19	9,000	30,500	9,000
8	....do	Dec. 1, 1892	313	River pebble	60.82	35,000	113,750	35,000
9	....do	Dec. 31, 1892	300	River pebble	61.76	25,000	120,284	25,000
10	....do	Dec. 31, 1892	300	River pebble	61.76	15,692	53,831	15,692
11	....do	Dec. 1, 1892	200	River pebble	67.37	4,000	12,000	4,000
12	....do	June 30, 1891	32	River pebble	67.56	600	(*a*)	....
13	....do	July 22, 1892	50	River pebble	60.00	500	1,500	500
14	....do	Dec. 1, 1892	150	River pebble	65.00	1,200	5,400	1,200
15	....do	Aug. 1, 1892	300	River pebble	60.71	9,106	31,871	7,226
16	....do	Dec. 1, 1892	80	River pebble	65.00	1,200	4,800	....
17	....do	Dec. 1, 1892	200	River pebble	61.08	4,600	16,100	4,600
18	....do	June 1, 1892	300	River pebble	62.00	11,250	50,625	11,250
19	South Carolina	Dec. 31, 1891	300	River rock	53.00	40,000	260,000	35,000
20	....do	Feb. 28, 1892	290	River rock	58.00	5,000	25,000	5,000
21	....do	Feb. 29, 1892	305	River rock	55.00	40,000	240,000	33,000
22	....do	Feb. 29, 1892	254	River rock	55.00	34,000	204,000	25,000
23	....do	Feb. 29, 1892	305	River rock	58.00	35,000	210,000	32.000
24	....do	Feb. 29, 1892	305	River rock	57.00	100,000	650,000	90.000
25	....do	(*a*)	300	River rock	55.00	15,000	97,500	13,000

a Not reported.

B.—GENERAL DESCRIPTION, CAPITAL INVESTED, ETC.

Establishment number.	Average thickness of deposit (feet).	Number of dredging appliances used.			Capacity of pumps per day (tons).	Miles of rivers controlled for mining purposes.	Capital invested in—	
		Centrifugal pumps.	Steam shovels.	Total.			-	Land.
1	3	1	....	1	60	4	$32,000	$53,000
2	7	2	....	2	150	10	65,000	75,000
3	(*a*)	2	....	2	80	14	40,000	75,000
4	5	1	....	1	100	1	25,000	7,000
5	4½	1	....	1	75	8	37,000	300,000
6	2	2	....	2	90	10	100,000	30,000
7	2	2	....	2	100	8	60,000	140,000
8	4	3	....	3	300	45	100,000	200,000
9	5	3	....	3	300	23	100,000	300,000
10	6	2	....	2	100	3	40,000	260,000
11	1½	1	....	1	100	2	(*a*)	(*a*)
12	8	1	....	1	40	(*a*)	45,000	200,000
13	(*a*)	(*b*)	(*b*)	(*b*)	....	½	(*a*)	(*a*)
14	8	1	....	1	(*a*)	(*a*)	15,000	35,000
15	1½	1	....	1	35	7	37,000	(*a*)
16	6	1	....	1	70	(*a*)	40,000	20,000
17	4	1	....	1	100	3	25,000	1,000
18	1½	2	....	2	70	25	50,000	50,000
19	(*a*)	....	2	2	....	(*a*)	50,000	....
20	(*a*)	(*b*)	(*b*)	(*b*)	....	(*a*)	1,200	....
21	(*a*)	....	2	2	....	(*a*)	300,000	30,000
22	(*a*)	....	1	1	....	(*a*)	300,000	....
23	(*a*)	....	3	3	....	(*a*)	40,000	25,000
24	(*a*)	....	3	3	....	7	500,000	....
25	(*a*)	....	1	1	....	(*a*)	100,000	....

a Not reported.
b Mined entirely by hand, no machinery being used.

TABLE II.—COST OF PRODUCTION OF PHOSPHATE IN THE UNITED STATES, 1890–1892—RIVER MINES—Continued.

C.—DISTANCE, MEANS, AND COST OF TRANSPORTATION.

Establishment number.	Primary shipping point.		Cost of transportation per ton of 2,240 pounds.				Place of free delivery to purchaser.	
	Miles from mine.	On railroad or river.	From mine to railroad or river station.	From railroad or river station to port of shipment out of state.	From port of shipment out of state to—		Miles from mine.	Cost of transportation per ton of 2,240 pounds.
					Domestic selling port.	Foreign selling port.		
1	......	Railroad	....	$1.52	$2.25	$4.50	(a)	(a)
2	......	River	....	.50	2.00	4.00	35	$0.50
3	......	River	....	b .13	1.92	(a)	30	b .13
4	......	River	....	.50	2.00	5.00	10	.50
5	......	Railroad	....	2.00	2.12½	4.50	200	2.00
6	......	River	....	.75	2.50	5.00	(a)	(a)
7	......	Railroad	....	(a)	(a)	(a)	(a)	(a)
8	......	Both	....	.75	2.50	5.00	55	.75
9	......	Both	....	.45	(a)	(a)	(a)	(a)
10	......	Both	....	.72	(a)	(a)	(a)	(a)
11	......	Railroad	....	1.80	2.25	4.25	(a)	(a)
12	......	Railroad	....	1.70	2.25	4.75	(a)	(a)
13	2	Railroad	b $0.35	2.50	(a)	(a)	2	b .35
14	......	Railroad	....	1.50	2.00	4.50	63	1.50
15	......	River	....	b .25	2.10	4.25	8	b .25
16	......	Railroad	....	(a)	(a)	(a)	(a)	(a)
17	......	River	....	b .60	2.00	4.00	16	b .60
18	......	Railroad	....	(a)	(a)	(a)	(c)	(c)
19	......	River	....	(d)	2.25	(a)	(c)	(c)
20	......	River	....	(d)	2.00	(a)	(c)	(c)
21	......	River	....	(d)	2.12½	4.80	(c)	(c)
22	......	River	....	(d)	2.12½	4.50	(c)	(c)
23	......	River	....	(d)	2.12½	4.80	(c)	(c)
24	......	River	....	(d)	2.12½	4.80	(c)	(c)
25	......	River	....	(d)	1.37½	(a)	(c)	(c)

a Not reported.
b Included in the cost of wages, and supplies and repairs.
c Sold at mine.
d Loaded on ship near mines by mine lighter.

D.—GENERAL STATEMENT OF COST FOR THE PERIOD.

[Insurance, interest, depreciation of value of plant, and charges for freight of product to place of free delivery are not included.]

Establishment number.	Labor.	Officials and clerks.	Supplies and repairs.	Taxes.	Royalty to the state.	Total.
1	$7,822	$3,600	$4,191	$20	(a)	$15,633
2	7,400	2,000	4,500	125	$6,000	20,025
3	9,452	3,000	5,200	(b)	(a)	c 17,652
4	5,275	2,000	5,200	25	2,321	14,821
5	3,450	3,330	900	....	(a)	7,680
6	9,415	3,700	4,250	181	5,625	23,171
7	5,000	7,000	1,500	225	(a)	13,725
8	18,512	3,500	9,700	350	(a)	32,062
9	24,373	3,000	11,295	640	(a)	39,308
10	12,630	1,500	9,372	546	(a)	24,048
11	5,400	1,900	3,500	(b)	(a)	e 10,800
12	338	240	200	(b)	(a)	c 778
13	500	400	380	....	(a)	1,280
14	3,100	1,000	190	63	(a)	4,353
15	12,181	5,857	6,520	45	(a)	24,603
16	2,256	1,500	550	100	(a)	4,406
17	5,170	2,400	2,150	150	3,450	13,320
18	11,880	6,600	1,125	350	(a)	19,955
19	32,600	1,800	17,000	1,250	40,000	92,650
20	15,000	(d)	900	10	5,000	20,910
21	31,143	4,000	8,303	1,525	40,000	84,971
22	35,043	4,600	7,412	600	34,000	81,655
23	65,972	(b)	19,737	1,070	35,000	e 121,779
24	146,781	(b)	31,646	1,656	100,000	e 280,083
25	f 24,659	(f)	(b)	(b)	15,000	g 39,659

a The right of the state to demand royalty from persons mining unnavigable streams is now in litigation. Bonds have been given to the state to secure the payment of such royalties should the suit be decided in its favor, but no payments have been made.
b Not reported. *c* Not including taxes. *d* Managed by owner. *e* Not including officials and clerks.
f The expenditures for officials and clerks are inseparably combined with those for labor.
g Not including supplies and repairs, and taxes.

TABLE II.—COST OF PRODUCTION OF PHOSPHATE IN THE UNITED STATES, 1890-1892—RIVER MINES—Continued.

E.—ELEMENTS OF COST IN ONE TON OF 2,240 POUNDS.

[Insurance, interest, depreciation of value of plant, and charges for freight of product to place of free delivery are not included.]

Establishment number.	Labor.	Officials and clerks.	Supplies and repairs.	Taxes.	Royalty to the state.	Total.
1	$1.499	$0.690	$0.803	$0.004	(*a*)	$2.996
2	.925	.250	.562	.016	$0.750	2.503
3	.788	.250	.433	(*b*)	(*a*)	*c* 1.471
4	1.137	.431	1.120	.005	.500	3.193
5	.545	.526	.142	....	(*a*)	1.213
6	1.255	.493	.567	.024	.750	3.089
7	.555	.778	.167	.025	(*a*)	1.525
8	.529	.100	.277	.010	(*a*)	.916
9	.975	.120	.452	.025	(*a*)	1.572
10	.805	.096	.597	.035	(*a*)	1.533
11	1.350	.475	.875	(*b*)	(*a*)	*c* 2.700
12	.564	.400	.333	(*b*)	(*a*)	*c* 1.297
13	1.000	.800	.760	....	(*a*)	2.560
14	2.584	.833	.158	.053	(*a*)	3.628
15	1.338	.643	.716	.005	(*a*)	2.702
16	1.880	1.250	.459	.083	(*a*)	3.672
17	1.124	.522	.467	.033	.750	2.896
18	1.056	.587	.100	.031	(*a*)	1.774
19	.815	.045	.425	.031	1.000	2.316
20	3.000	(*d*)	.180	.002	1.000	4.182
21	.779	.100	.207	.038	1.000	2.124
22	1.031	.135	.218	.018	1.000	2.402
23	1.885	(*b*)	.564	.031	1.000	*e* 3.480
24	1.468	(*b*)	.316	.017	1.000	*e* 2.801
25	*f* 1.644	(*f*)	(*b*)	(*b*)	1.000	*g* 2.644

a The right of the state to demand royalty from persons mining unnavigable streams is now in litigation. Bonds have been given to the state to secure the payment of such royalties should the suit be decided in its favor, but no payments have been made.

b Not reported. *c* Not including taxes. *d* Managed by owner. *e* Not including officials and clerks.

f The expenditures for officials and clerks are inseparably combined with those for labor.

g Not including supplies and repairs, and taxes.

F.—PER CENT. OF EACH ELEMENT OF COST IN ONE TON OF 2,240 POUNDS.

[Insurance, interest, depreciation of value of plant, and charges for freight of product to place of free delivery are not included.]

Establishment number.	Labor.	Officials and clerks.	Supplies and repairs.	Taxes.	Royalty to the state.	Total.
1	50.03	23.03	26.81	.13	(*a*)	100
2	36.95	9.99	22.47	.63	29.96	100
3	53.55	16.99	29.46	(*b*)	(*a*)	*c* 100
4	35.59	13.49	35.09	.17	15.66	100
5	44.92	43.36	11.72	....	(*a*)	100
6	40.63	15.97	18.34	.78	24.28	100
7	36.43	51.00	10.93	1.64	(*a*)	100
8	57.74	10.92	30.25	1.09	(*a*)	100
9	62.01	7.63	28.73	1.63	(*a*)	100
10	52.52	6.24	38.97	2.27	(*a*)	100
11	50.00	17.59	32.41	(*b*)	(*a*)	*c* 100
12	43.44	30.85	25.71	(*b*)	(*a*)	*c* 100
13	39.06	31.25	29.69	....	(*a*)	100
14	71.22	22.97	4.36	1.45	(*a*)	100
15	49.51	23.81	26.50	.18	(*a*)	100
16	51.20	34.05	12.48	2.27	(*a*)	100
17	38.81	18.02	16.14	1.13	25.90	100
18	59.53	33.08	5.64	1.75	(*a*)	100
19	35.19	1.94	18.35	1.35	43.17	100
20	71.74	(*d*)	4.30	.05	23.91	100
21	36.65	4.71	9.77	1.79	47.08	100
22	42.92	5.63	9.08	.73	41.64	100
23	54.17	(*b*)	16.21	.88	28.74	*e* 100
24	52.41	(*b*)	11.30	.59	35.70	*e* 100
25	*f* 62.18	(*f*)	(*b*)	(*b*)	37.82	*g* 100

a The right of the state to demand royalty from persons mining unnavigable streams is now in litigation. Bonds have been given to the state to secure the payment of such royalties should the suit be decided in its favor, but no payments have been made.

b Not reported. *c* Not including taxes. *d* Managed by owner. *e* Not including officials and clerks.

f The expenditures for officials and clerks are inseparably combined with those for labor.

g Not including supplies and repairs, and taxes.

TABLE II.—COST OF PRODUCTION OF PHOSPHATE IN THE UNITED STATES, 1890-1892—RIVER MINES—Continued.

G.—ADDITIONAL COST OF CERTAIN THEORETICAL ELEMENTS FOR THE PERIOD.

Establishment number.	Insurance.	Interest.	Depreciation of value of plant.	Transportation to place of free delivery.	Total.
1	$210	$600		$10,500	$11,310
2	(*a*)	(*a*)	(*a*)	4,000	*b* 4,000
3	(*a*)	(*a*)	(*a*)		(*a*)
4	150	500	$5,000	2,321	7,971
5	325		506	9,776	10,601
6	1,250	(*a*)	5,000	22,850	*c* 29,100
7	350			10,000	10,350
8	750	(*a*)	5,000	26,250	*c* 32,000
9	2,250			123,750	126,000
10	1,000			81,912	82,912
11	380	(*a*)		3,200	*c* 3,580
12	(*a*)	(*a*)	(*a*)		(*a*)
13					
14	49		900	1,800	2,749
15	176				176
16	200				200
17					
18	250				250
19			5,000		5,000
20			250		250
21	750		5,000		5,750
22	375		6,000		6,375
23			20,000		20,000
24			30,000		30,000
25	(*a*)	(*a*)	(*a*)		(*a*)

a Not reported.
b Not including insurance, interest, and depreciation of value of plant.
c Not including interest.

H.—ADDITIONAL COST OF CERTAIN THEORETICAL ELEMENTS IN ONE TON OF 2,240 POUNDS.

Establishment number.	Insurance.	Interest.	Depreciation of value of plant.	Transportation to place of free delivery.	Total.
1	$0.040	$0.115		$2.012	$2.167
2	(*a*)	(*a*)	(*a*)	.500	*b* .500
3	(*a*)	(*a*)	(*a*)		(*a*)
4	.032	.108	$1.078	.500	1.718
5	.051		.079	2.000	2.130
6	.167	(*a*)	.666	4.155	*c* 4.988
7	.039			1.111	1.150
8	.021	(*a*)	.143	.750	*c* .914
9	.090			4.950	5.040
10	.064			5.220	5.284
11	.095	(*a*)		.800	*c* .895
12	(*a*)	(*a*)	(*a*)		(*a*)
13					
14	.041		.750	1.500	2.291
15	.019				.091
16	.167				.167
17					
18	.022				.022
19			.125		.125
20			.050		.050
21	.019		.125		.144
22	.011		.177		.188
23			.571		.571
24			.300		.300
25	(*a*)	(*a*)	(*a*)		(*a*)

a Not reported.
b Not including insurance, interest, and depreciation of value of plant.
c Not including interest.

TABLE II.—COST OF PRODUCTION OF PHOSPHATE IN THE UNITED STATES, 1890-1892—RIVER MINES—Continued.

J.—RATES OF WAGES.

Establishment number.	Occupation.	Hours per day.	Average employés for period.	Daily rate of pay or average daily earnings.
1	Engineers	10	2	$2.88
	Firemen	10	3	1.50
	Laborers	10	13	1.25
	Nozzlemen	10	2	1.35
	Watchmen	10	2	1.50
	Total	10	22	1.46½
2	Captain, dredge	10	1	2.30
	Dredgemen	10	2	1.25
	Engineers	10	2	2.30
	Firemen	10	3	1.25
	Foreman	10	1	2.87½
	Laborers	10	15	1.25
	Lightermen	10	4	1.25
	Watchman	10	1	1.15
	Total	10	29	1.41
3	Captain, tug	10	1	1.72½
	Engineers	10	4	1.55½
	Firemen	10	4	1.29½
	Foremen	10	2	2.87½
	Laborers	10	8	1.00
	Lightermen	10	2	1.00
	Pumpers	10	2	1.00
	Watchman	10	1	.98½
	Total	10	24	1.32½
4	Captain, tug	10	1	2.52½
	Carpenter	10	1	2.50
	Cook	10	1	.83½
	Engineers	10	3	2.22
	Fireman	10	1	1.16½
	Foreman	10	1	3.00
	Laborers	10	20	1.25
	Total	10	28	1.49
5	Captains, barge	10	3	1.33½
	Captain, dredge	10	1	2.50
	Engineers	10	3	1.96½
	Fireman	10	1	1.50
	Laborers	10	6	1.25
	Watchman	10	1	1.48
	Total	10	15	1.52½
6	Captains, dredge	10	2	2.30
	Carpenters	10	2	2.50
	Engineers	10	3	2.30
	Foreman	10	1	2.87½
	Laborers	10	18	1.25
	Watchman	10	1	1.48
	Total	10	27	1.60½
7	Engineers	10	4	3.35½
	Firemen	10	3	1.53½
	Laborers	10	10	1.10
	Lightermen	10	6	1.04
	Teamsters	10	2	1.00
	Watchman	10	1	1.31½
	Total	10	26	1.48½
8	Carpenter	10	1	2.50
	Engineers	12	6	1.50
	Engineer, locomotive.	12	1	2.50
	Foreman	12	1	3.85
	Laborers	12	30	1.36½
	Total	......	39	1.51
9	Captains	10	5	$2.29
	Cooks	10	4	.99
	Dumpers	10	3	1.16½
	Engineers	10	6	2.37
	Fireman	10	1	1.40
	Foremen	10	3	1.90½
	Laborers	10	23	1.10
	Machinists	10	3	3.44½
	Mate	10	1	1.53½
	Oiler	10	1	1.20
	Watchman	10	1	1.50
	Total	10	51	1.57
10	Captains	12	2	2.00
	Carpenter	12	1	2.40
	Engineers	12	4	2.47½
	Fireman	12	1	1.50
	Foreman	12	1	2.00
	Laborers	12	9	1.50
	Machinist	10	1	3.60
	Mates	12	2	1.50
	Watchman	12	1	1.48
	Total	......	22	1.88
11	Firemen	10	2	1.50
	Foreman	10	1	2.50
	Laborers	10	15	1.25
	Nozzleman	10	1	1.50
	Watchman	10	1	1.60
	Total	10	20	1.36½
12	Engineer	10	1	2.87½
	Fireman	10	1	1.53½
	Mill hands	10	2	1.53½
	Teamsters	10	3	1.00
	Total	10	7	1.49½
13	Laborers	10	8	1.25
	Total	10	8	1.25
14	Engineer	10	1	2.00
	Foreman	10	1	2.50
	Laborers	10	15	1.00
	Watchman	10	1	1.25
	Total	10	18	1.15½
15	Captain	10	1	2.49
	Carpenters	10	3	2.10
	Engineers	10	2	2.58½
	Feeder	10	1	1.38
	Firemen	10	3	1.80½
	Laborers	10	8	1.25
	Watchman	10	1	1.00
	Total	10	19	1.67
16	Foreman	10	1	3.19½
	Laborers	10	20	1.25
	Total	10	21	1.34½
17	Captain	10	1	2.68½
	Dredgemen	10	3	1.80
	Engineers	10	2	2.21½
	Feeder	10	1	1.50
	Fireman	10	1	1.05½
	Foreman	10	1	3.00
	Laborers	10	3	1.18½
	Total	10	12	1.80

TABLE II.—COST OF PRODUCTION OF PHOSPHATE IN THE UNITED STATES, 1890-1892—**RIVER MINES**—Concluded.

J.—RATES OF WAGES—Concluded.

Establishment number.	Occupation.	Hours per day.	Average employés for period.	Daily rate of pay or average daily earnings.
18	Captain	10	1	$2.30
	Dredgemen	10	4	1.25
	Elevator men	10	4	1.25
	Engineers	10	2	2.30
	Firemen	10	3	1.25
	Foreman	10	1	2.30
	Laborers	10	7	1.25
	Lightermen	10	4	1.25
	Nozzleman	10	1	1.25
	Watchman	10	1	1.25
	Total	10	28	1.40
19	Captain, tug	10	1	3.83½
	Dumpers	10	4	1.00
	Engineers	10	3	1.98½
	Firemen	10	2	1.00
	Laborers	10	120	.70
	Machinists	10	3	2.81½
	Total	10	133	.81½
20	Laborers	(a)	50	1.00
	Total	......	50	1.00
21	Engineers	10	4	3.83½
	Firemen	10	4	1.15
	Laborers	10	62	1.31
	Total	10	70	1.44½
22	Dumpers	10	2	$1.00
	Engineers	10	3	3.58
	Firemen	10	3	1.15
	Laborers	10	90	1.25
	Total	10	98	1.31½
23	Engineers	10	4	3.33
	Foreman	10	1	6.33
	Laborers	10	171	1.15
	Total	10	176	1.23
24	Engineers Machine hands Machinists	10	25	3.26
	Foremen	10	7	3.50
	Laborers	10	315	1.15
	Total	10	347	1.35
25	Laborers (b)	10	54	1.11
	Total	10	54	1.11

a Variable.
b Skilled labor is not reported.

INDEX.

A.

Page.

Account of daily expenses of a land pebble phosphate mine 61
Account of daily expenses of a plate rock phosphate mine 54
Account of daily expenses of a river pebble phosphate mine 65
Acreage of phosphate lands in Florida 41
Acreage of various cereals in the United States 16
Age of the phosphate basins of the Ashley 74
Agricultural products, per cent. of ash or mineral matter in certain 15
Agricultural products, quantity and value of, in the United States 15
Agricultural products, quantity of ash or mineral matter in a crop of, in the United States 15
Agricultural products, quantity of phosphoric acid in a crop of, in the United States 16
Amount and value of soft phosphate sold for consumption in Florida in 1890, 1891, and 1892 58
Analyses of composite phosphate 55
Analyses of Florida hard rock phosphate 46–48
Analyses of land pebble phosphate 60, 61
Analyses of phosphates from foreign countries 86
Analyses of plate rock phosphate 52, 54
Analyses of river pebble phosphate 65
Analyses of soft phosphate 57
Analyses of South Carolina rock phosphate 85, 86
Analyses of various types of native phosphate 28–31
Appliances, dredging, used and daily capacity of pumps in river mines 132
Area controlled for phosphate mining purposes in land mines 112, 113
Area controlled for phosphate mining purposes in river mines 132
Area controlled for phosphate mining purposes—summary 91
Area, estimated, of river mines in Florida 64
Ash or mineral matter, per cent. of, in certain agricultural products 15
Ash or mineral matter, quantity of, in a crop of cereals in the United States 15
Ashley fish bed, the 77
Ashley phosphate basins, age of 74

B.

Bone phosphate in land mines, per cent. of 110, 111
Bone phosphate in river mines, per cent. of 132

C.

Capital invested in Florida railroads, etc., for the accommodation of the phosphate trade 68, 69
Capital invested in land mines 112, 113
Capital invested in phosphate mining in the United States—summary 91
Capital invested in river mines 132
Cereals, acreage of various, in the United States 16
Cereals, quantity of ash or mineral matter in a crop of, in the United States 15
Cereals, quantity of phosphoric acid in a crop of, in the United States 16
Clerical labor and superintendence, cost of, in one ton of 2,240 pounds—land mines 118, 119
Clerical labor and superintendence, cost of, in one ton of 2,240 pounds—river mines 134
Clerical labor and superintendence, cost of—land mines 116, 117
Clerical labor and superintendence, cost of—river mines 133
Clerical labor and superintendence, per cent. cost of, in one ton of 2, 240 pounds—land mines 120, 121
Clerical labor and superintendence, per cent. cost of, in one ton of 2, 240 pounds—river mines 134
Commercial aspect of the phosphate industry 102–105
Commercial fertilizers, annual consumption of, in sixteen states, from 1875 to 1892 103
Comparative merits of the hard rock and pebble phosphate belts in Florida 40
Comparison of the several kinds of Florida phosphates 67
Composite phosphate, analyses of 55
Composite phosphate, description of 54, 55
Consumption and shipments of South Carolina phosphate from 1867 to 1892 97
Consumption and shipments of United States phosphate 96–102
Consumption, annual, of commercial fertilizers in sixteen states from 1875 to 1892 103
Consumption of phosphate of the world during 1891 (including United States) 101
Consumption of phosphate of the world during 1891 (not including United States) 101
Consumption of United States phosphate as indicated by shipments during 1891 101
Cost and means of transportation, with distance—land mines 114, 115
Cost and means of transportation, with distance—river mines 133
Cost of depreciation of value of plant in one ton of 2, 240 pounds—land mines 124, 125
Cost of depreciation of value of plant in one ton of 2, 240 pounds—river mines 135
Cost of depreciation of value of plant—land mines 122, 123

Page.

Cost of depreciation of value of plant—river mines 135
Cost of insurance in one ton of 2,240 pounds—land mines 124, 125
Cost of insurance in one ton of 2,240 pounds—river mines 135
Cost of insurance—land mines 122, 123
Cost of insurance—river mines 135
Cost of interest in one ton of 2,240 pounds—land mines 124, 125
Cost of interest in one ton of 2,240 pounds—river mines 135
Cost of interest—land mines 122, 123
Cost of interest—river mines 135
Cost of labor in one ton of 2,240 pounds—land mines 118, 119
Cost of labor in one ton of 2,240 pounds—river mines 134
Cost of labor—land mines 116, 117
Cost of labor—river mines 133
Cost of production of phosphate in Florida—summary 92, 94
Cost of production of phosphate in North Carolina—summary 92
Cost of production of phosphate in South Carolina—summary 93, 95
Cost of production of phosphate in the United States 92–96
Cost of production of phosphate in the United States, 1890–1892—land mines 110–131
Cost of production of phosphate in the United States, 1890–1892—river mines 132–137
Cost of royalty to owners of the soil in one ton of 2,240 pounds—land mines 124, 125
Cost of royalty to owners of the soil—land mines 122, 123
Cost of royalty to the state in one ton of 2,240 pounds—river mines 134
Cost of royalty to the state—river mines 133
Cost of superintendence and clerical labor in one ton of 2,240 pounds—land mines 118, 119
Cost of superintendence and clerical labor in one ton of 2,240 pounds—river mines 134
Cost of superintendence and clerical labor—land mines 116, 117
Cost of superintendence and clerical labor—river mines 133
Cost of supplies and repairs in one ton of 2,240 pounds—land mines 120, 121
Cost of supplies and repairs in one ton of 2,240 pounds—river mines 134
Cost of supplies and repairs—land mines 116, 117
Cost of supplies and repairs—river mines 133
Cost of taxes in one ton of 2,240 pounds—land mines 120, 121
Cost of taxes in one ton of 2,240 pounds—river mines 134
Cost of taxes—land mines 116, 117
Cost of taxes—river mines 133
Cost of theoretical elements of production in one ton of 2,240 pounds—land mines 124, 125
Cost of theoretical elements of production in one ton of 2,240 pounds—river mines 135
Cost of theoretical elements of production—land mines 122, 123
Cost of theoretical elements of production—river mines 135
Cost of transportation to place of free delivery in one ton of 2,240 pounds—land mines 124, 125
Cost of transportation to place of free delivery in one ton of 2,240 pounds—river mines 135
Cost of transportation to place of free delivery—land mines 122, 123
Cost of transportation to place of free delivery—river mines 135

D.

Deposit, average depth of, from surface in land mines 112, 113
Deposit, average thickness of, in land mines 112, 113
Deposit, average thickness of, in river mines 132
Depreciation of value of plant, cost of, in one ton of 2,240 pounds—land mines 124, 125
Depreciation of value of plant, cost of, in one ton of 2,240 pounds—river mines 135
Depreciation of value of plant, cost of—land mines 122, 123
Depreciation of value of plant, cost of—river mines 135
Depth of deposit (average) from surface in land mines 112, 113
Description and names of phosphate rocks 73, 74
Discovery of phosphate in Florida 36–39
Discovery of phosphate in South Carolina 77–82
Distance, means, and cost of transportation—land mines 114, 115
Distance, means, and cost of transportation—river mines 133
Dredging appliances used and daily capacity of pumps in river mines 132

E.

Earnings, average annual, and number of employés in phosphate mining in the United States—summary 91
Earnings, average daily, of employés in land mines, by occupations 126–131
Earnings, average daily, of employés in river mines, by occupations 136, 137
Employés in land mines, average number of, by occupations 126–131
Employés in river mines, average number of, by occupations 136, 137
English market prices (average) of phosphate 102
English market prices of phosphate from 1882 to 1891 102
Estimated phosphate in sight in Florida 40–42
Expenditure for labor in phosphate mining in the United States—summary 91
Expense account, daily, of a land pebble phosphate mine 61
Expense account, daily, of a plate rock phosphate mine 54
Expense account, daily, of a river pebble phosphate mine 65

F.

Farm products, per cent. of ash or mineral matter in certain 15
Farm products, quantity and value of, in the United States 15
Farm products, quantity of ash or mineral matter in a crop of, in the United States 15
Farm products, quantity of phosphoric acid in a crop of, in the United States 16
Fertilizers, commercial, annual consumption of, in sixteen states, from 1875 to 1892 103

Page.

Fertilizers, extracts from letters, etc., relating to 14-19
Fertilizing materials imported during the year ending June 30, 1892 105
Fish bed of the Ashley 77
Florida and South Carolina phosphate deposits, favorable location of 10
Florida and South Carolina phosphate industry, consideration of 11
Florida, cost of production of phosphate in—summary 92, 94
Florida, discovery of phosphate in 36-39
Florida, estimated phosphate in sight in 40-42
Florida, extract from law authorizing phosphate mining in the navigable waters of 67
Florida, general observations on the phosphate industry in 66-69
Florida hard rock and pebble belts, comparative merits of 40
Florida hard rock phosphate, analyses of 46-48
Florida, kinds of phosphate, machinery used, etc., in 42-66
Florida phosphate belt, geographical position of 31-34
Florida phosphate belt, topography of 34, 35
Florida phosphate fields, geology of 23-31
Florida, phosphate industry of 21-69
Florida phosphate, shipments of, from 1888 to 1892 99
Florida phosphate, shipments of, through United States custom-houses, for the years 1891 and 1892 98
Florida phosphates, comparison of the several kinds of 67
Florida phosphates, relative selling price in London of various 68
Florida railroads, etc., capital invested in, for the accommodation of the phosphate trade 68, 69
Foreign countries, analyses of phosphates from 86
Fossils and petrifactions 76, 77

G.

General observations on the phosphate industry in Florida 66-69
General statistics of the phosphate industry 87-137
Geographical position of the Florida phosphate belt 31-34
Geological wonder, Tate's shaft considered a 65, 66
Geology of the phosphate fields of Florida 23-31
Geology of the phosphate fields of South Carolina 73-77
Grains, acreage of various, in the United States 16
Grains, quantity of ash or mineral matter in a crop of, in the United States 15
Grains, quantity of phosphoric acid in a crop of, in the United States 16
Gravel screenings phosphate, description of 50, 51
Great Britain, method of selling phosphate in 68
Guano, introduction of, from Peru 13

H.

Hard rock and pebble phosphate belts in Florida, comparative merits of 40
Hard rock phosphate, description of the mineral and its mining 42-50
Hard rock phosphate of Florida, analyses of 46-48
Hay, quantity of ash and phosphoric acid in 16
Historic or recent geological age 74, 75
Hours of labor of employés in land mines, by occupations 126-131
Hours of labor of employés in river mines, by occupations 136, 137

I.

Imports of fertilizing materials during the year ending June 30, 1892 105
Increase, relative, in the shipments of South Carolina phosphate by five-year and ten-year periods 100
Insurance, cost of, in one ton of 2,240 pounds—land mines 124, 125
Insurance, cost of, in one ton of 2,240 pounds—river mines 135
Insurance, cost of—land mines 122, 123
Insurance, cost of—river mines 135
Interest, cost of, in one ton of 2,240 pounds—land mines 124, 125
Interest, cost of, in one ton of 2,240 pounds—river mines 135
Interest, cost of—land mines 122, 123
Interest, cost of—river mines 135

L.

Labor, cost of, in one ton of 2,240 pounds—land mines 118, 119
Labor, cost of, in one ton of 2,240 pounds—river mines 134
Labor, cost of—land mines 116, 117
Labor, cost of—river mines 133
Labor expense in phosphate mining in the United States—summary 91
Labor, hours of, of employés in land mines, by occupations 126-131
Labor, hours of, of employés in river mines, by occupations 136, 137
Labor opportunities in the phosphate industry 106-108
Labor, per cent. cost of, in one ton of 2,240 pounds—land mines 120, 121
Labor, per cent. cost of, in one ton of 2,240 pounds—river mines 134
Laminated hard rock phosphate, description of 42, 43
Land and river rock phosphate, description of 83
Land mines, area controlled for mining purposes in 112, 113
Land mines, average daily rates of wages of employés in, by occupations 126-131
Land mines, average depth of deposits from surface in 112, 113
Land mines, average number of employés in, by occupations 126-131

Page.
Land mines, average thickness of deposit in ... 112, 113
Land mines, capital invested in ... 112, 113
Land mines, cost of depreciation of value of plant in ... 122, 123
Land mines, cost of depreciation of value of plant in one ton of 2,240 pounds in ... 124, 125
Land mines, cost of insurance in ... 122, 123
Land mines, cost of insurance in one ton of 2,240 pounds in ... 124, 125
Land mines, cost of interest in ... 122, 123
Land mines, cost of interest in one ton of 2,240 pounds in ... 124, 125
Land mines, cost of labor in ... 116, 117
Land mines, cost of labor in one ton of 2,240 pounds in ... 118, 119
Land mines, cost of production of phosphate in the United States in 1890, 1891, and 1892, in ... 110–131
Land mines, cost of royalty to owners of the soil in ... 122, 123
Land mines, cost of royalty to owners of the soil in one ton of 2,240 pounds in ... 124, 125
Land mines, cost of superintendence and clerical labor in ... 116, 117
Land mines, cost of superintendence and clerical labor in one ton of 2,240 pounds in ... 118, 119
Land mines, cost of supplies and repairs in ... 116, 117
Land mines, cost of supplies and repairs in one ton of 2,240 pounds in ... 118, 119
Land mines, cost of taxes in ... 116, 117
Land mines, cost of taxes in one ton of 2,240 pounds in ... 118, 119
Land mines, cost of theoretical elements of production in ... 122, 123
Land mines, cost of theoretical elements of production in one ton of 2,240 pounds in ... 124, 125
Land mines, cost of transportation to place of free delivery in ... 122, 123
Land mines, cost of transportation to place of free delivery in one ton of 2,240 pounds in ... 124, 125
Land mines, distance, means, and cost of transportation in ... 114, 115
Land mines, hours of labor of employés in, by occupations ... 126–131
Land mines, per cent. cost of labor in one ton of 2,240 pounds in ... 120, 121
Land mines, per cent. cost of superintendence and clerical labor in one ton of 2,240 pounds in. 120, 121
Land mines, per cent. cost of supplies and repairs in one ton of 2,240 pounds in ... 120, 121
Land mines, per cent. cost of taxes in one ton of 2,240 pounds in ... 120, 121
Land mines, per cent. of bone phosphate in ... 110, 111
Land mines, quantity and value of phosphate mined at ... 110, 111
Land mines, quantity of phosphate shipped from ... 110, 111
Land mines, running time of ... 110, 111
Land mining of phosphate in South Carolina ... 83, 84
Land pebble phosphate, analyses of ... 60, 61
Land pebble phosphate, description of ... 58–61
Land pebble phosphate mine, daily running expenses of a ... 61
Law authorizing phosphate mining in the navigable waters of Florida (extract) ... 67
Liebig, method of making phosphate of lime soluble, discovered by ... 13
Location and character of North Carolina phosphate deposits ... 12
Location of phosphate industry ... 9

M.

Machinery used, kinds of phosphate, etc., in Florida ... 42–66
Machinery used, kinds of phosphate, etc., in South Carolina ... 83–85
Means and cost of transportation, with distance—land mines ... 114, 115
Means and cost of transportation, with distance—river mines ... 133
Method of selling phosphate in foreign markets ... 68
Mineral matter or ash, per cent. of, in certain agricultural products ... 15
Mineral matter or ash, quantity of, in a crop of cereals in the United States ... 15
Mining phosphates in the navigable waters of Florida, law authorizing (extract) ... 67

N.

Names given to the phosphate rocks and general description ... 73, 74
North Carolina, cost of production of phosphate in—summary ... 92
North Carolina phosphate deposits, location and character of ... 12

O.

Observations, general, on the phosphate industry in Florida ... 66–69
Opportunities for labor in the phosphate industry ... 106–108
Origin of the phosphate rocks, theories concerning ... 75, 76

P.

Pebble and hard rock phosphate belts in Florida, comparative merits of ... 40
Pebble, land, phosphate, analyses of ... 60, 61
Pebble, land, phosphate, description of ... 58–61
Pebble, land, phosphate mine, daily running expenses of a ... 61
Pebble, river, phosphate, analyses of ... 65
Pebble, river, phosphate, description of ... 61–65
Pebble, river, phosphate mine, daily running expenses of a ... 65
Percentage of bone phosphate in land mines ... 110, 111
Percentage of bone phosphate in river mines ... 132
Peru, introduction of guano from ... 13
Petrifactions and fossils ... 76, 77
Phosphate basins of the Ashley, age of ... 74
Phosphate belt, Florida, geographical position of ... 31–34
Phosphate belt, Florida, topography of ... 34, 35
Phosphate, composite, analyses of ... 55
Phosphate, composite, description of ... 54, 55
Phosphate consumption of the world during 1891 (including United States) ... 101
Phosphate consumption of the world during 1891 (not including United States) ... 101

Page.
Phosphate, cost of production of, in Florida—summary 92, 94
Phosphate, cost of production of, in North Carolina—summary 92
Phosphate, cost of production of, in South Carolina—summary 93, 95
Phosphate, cost of production of, in the United States 92-96
Phosphate, cost of production of, in the United States, 1890-1892—land mines 110-131
Phosphate, cost of production of, in the United States, 1890-1892—river mines 132-137
Phosphate deposits of Florida and South Carolina, favorable location of 10
Phosphate deposits of North Carolina, location and character of 12
Phosphate fields of Florida, geology of 23-31
Phosphate fields of South Carolina, geology of 73-77
Phosphate formations, all found in Tate's shaft—a geological wonder 65, 66
Phosphate, gravel screenings, description of 50, 51
Phosphate, hard rock, analyses of Florida 46-48
Phosphate, hard rock, description of 42-50
Phosphate in Florida, discovery of 36-39
Phosphate in sight in Florida, estimated amount of 40-42
Phosphate in South Carolina, discovery of 77-82
Phosphate industry, commercial aspect of 102-105
Phosphate industry, general statistics of 87-137
Phosphate industry, location of 9
Phosphate industry of Florida 21-69
Phosphate industry of Florida, general observations on 66-69
Phosphate industry of South Carolina 71-86
Phosphate industry of South Carolina and Florida, consideration of 11
Phosphate industry of South Carolina, growth of 9
Phosphate industry, opportunities for labor in 106-108
Phosphate, kinds of, machinery used, etc., in Florida 42-66
Phosphate, kinds of, machinery used, etc., in South Carolina 83-85
Phosphate, laminated hard rock, description of 42, 43
Phosphate, land and river rock, description of 83
Phosphate, land pebble, analyses of 60, 61
Phosphate, land pebble, description of 58-61
Phosphate lands in Florida, acreage of 41
Phosphate mined in the United States, consumption of, as indicated by shipments during 1891 101
Phosphate mined, quantity and value of, at land mines 110, 111
Phosphate mined, quantity and value of, at river mines 132
Phosphate mining in the navigable waters of Florida, law authorizing (extract) 67
Phosphate mining in the United States, summary table showing quantity mined, value at mine, quantity shipped, area controlled for mining purposes, capital invested, expenses for labor, and number and wages of employés in 91
Phosphate, native, analyses of various types of 28-31
Phosphate, plate rock, analyses of 52, 54
Phosphate, plate rock, description of 51-54
Phosphate prices (average) in the English market 102
Phosphate prices in the English market from 1882 to 1891 102
Phosphate production of the world for 1891 (including United States) 102
Phosphate production of the world for 1891 (not including United States) 101
Phosphate, river pebble, analyses of 65
Phosphate, river pebble, description of 61-65
Phosphate rocks, their origin 75, 76
Phosphate rocks, their various names and general description 73, 74
Phosphate selling in foreign markets, method of 68
Phosphate, shipments and consumption of South Carolina, from 1867 to 1892 97
Phosphate, shipments and consumption of, United States 96-102
Phosphate shipments in 1891 and 1892, quantity and value of 104
Phosphate, shipments of Florida, from 1888 to 1892 99
Phosphate, shipments of Florida, through United States custom-houses, for the years 1891 and 1892 98
Phosphate shipped from land mines, quantity of 110, 111
Phosphate shipped from river mines, quantity of 132
Phosphate, soft, analyses of 57
Phosphate, soft, description of 55-58
Phosphate, soft, sold for consumption in Florida in 1890, 1891, and 1892, quantity and value of 58
Phosphates as fertilizers, extracts from letters, etc., relating to 14-19
Phosphates of Florida, comparison of the several kinds of 67
Phosphates of Florida, relative selling price in London of various 68
Phosphoric acid, quantity of, in a crop of cereals in the United States 16
Plate rock phosphate, analyses of 52, 54
Plate rock phosphate, description of 51-54
Plate rock phosphate mine, daily running expenses of a 54
Prices (average) of phosphate in the English market 102
Prices of phosphate in the English market from 1882 to 1891 102
Prices of various Florida phosphates sold in London 68
Production, cost of, of phosphate in Florida—summary 92, 94
Production, cost of, of phosphate in North Carolina—summary 92
Production, cost of, of phosphate in South Carolina—summary 93, 95
Production, cost of, of phosphate in the United States 92-96
Production, cost of, of phosphate in the United States, 1890-1892—land mines 110-131
Production, cost of, of phosphate in the United States, 1890-1892—river mines 132-137
Production of phosphate of the world for 1891 (including United States) 102
Production of phosphate of the world for 1891 (not including United States) 101
Pumps, daily capacity of, and dredging appliances used in river mines 132

Q.

Quantity and value of phosphate mined at land mines 110, 111
Quantity and value of phosphate mined at river mines 132

Page.
Quantity and value of phosphate shipments in 1891 and 1892 104
Quantity and value of soft phosphate sold for consumption in Florida in 1890, 1891, and 1892 .. 58
Quantity of phosphate mined in the United States—summary 91
Quantity of phosphate shipped from land mines 110, 111
Quantity of phosphate shipped from river mines 132
Quantity of phosphate shipped from the United States—summary 91

R.

Railroads, etc., in Florida, capital invested in, for the accommodation of the phosphate trade. 68, 69
Rates of wages and number of employés, by occupations 106
Rates of wages, daily, of employés in land mines, by occupations 126–131
Rates of wages, daily, of employés in river mines, by occupations 136, 137
Recent or historic geological age 74, 75
Repairs and supplies, cost of, in one ton of 2,240 pounds—land mines 118, 119
Repairs and supplies, cost of, in one ton of 2,240 pounds—river mines 134
Repairs and supplies, cost of—land mines 116, 117
Repairs and supplies, cost of—river mines 133
Repairs and supplies, per cent. cost of, in one ton of 2,240 pounds—land mines 120, 121
Repairs and supplies, per cent. cost of, in one ton of 2,240 pounds—river mines 134
River and land rock phosphate, description of 83
River mines, area controlled for mining purposes in 132
River mines, average daily rates of wages of employés in, by occupations 136, 137
River mines, average number of employés in, by occupations 136, 137
River mines, average thickness of deposit in 132
River mines, capital invested in 132
River mines, cost of depreciation of value of plant in 135
River mines, cost of depreciation of value of plant in one ton of 2,240 pounds in 135
River mines, cost of insurance in 135
River mines, cost of insurance in one ton of 2,240 pounds in 135
River mines, cost of interest in 135
River mines, cost of interest in one ton of 2,240 pounds in 135
River mines, cost of labor in 133
River mines, cost of labor in one ton of 2,240 pounds in 134
River mines, cost of production of phosphate in the United States in 1890, 1891, and 1892, in 132–137
River mines, cost of royalty to the state in 133
River mines, cost of royalty to the state in one ton of 2,240 pounds in 134
River mines, cost of superintendence and clerical labor in 133
River mines, cost of superintendence and clerical labor in one ton of 2,240 pounds in 134
River mines, cost of supplies and repairs in 133
River mines, cost of supplies and repairs in one ton of 2,240 pounds in 134
River mines, cost of taxes in 133
River mines, cost of taxes in one ton of 2,240 pounds in 134
River mines, cost of theoretical elements of production in 135
River mines, cost of theoretical elements of production in one ton of 2,240 pounds in 135
River mines, cost of transportation to place of free delivery in 135
River mines, cost of transportation to place of free delivery in one ton of 2,240 pounds in 135
River mines, distance, means, and cost of transportation in 133
River mines, dredging appliances used and daily capacity of pumps in 132
River mines, estimated area of, in Florida 64
River mines, hours of labor of employés in, by occupations 136, 137
River mines, per cent. cost of labor in one ton of 2,240 pounds in 134
River mines, per cent. cost of royalty to the state in one ton of 2,240 pounds in 134
River mines, per cent. cost of superintendence and clerical labor in one ton of 2,240 pounds in .. 134
River mines, per cent. cost of supplies and repairs in one ton of 2,240 pounds in 134
River mines, per cent. cost of taxes in one ton of 2,240 pounds in 134
River mines, per cent. of bone phosphate in 132
River mines, quantity and value of phosphate mined at 132
River mines, quantity of phosphate shipped from 132
River mines, running time of 132
River mining of phosphate in South Carolina, description of 84, 85
River pebble phosphate, analyses of 65
River pebble phosphate, description of 61–65
River pebble phosphate mine, daily running expenses of a 65
Rivers, navigable, of Florida, extract from law authorizing phosphate mining in 67
Rock phosphate of South Carolina, analyses of 85, 86
Royalties paid to South Carolina on phosphate from 1870 to 1892 105
Royalty to owners of the soil in land mines, cost of 122, 123
Royalty to owners of the soil in one ton of 2,240 pounds, cost of—land mines 124, 125
Royalty to the state in one ton of 2,240 pounds, cost of—river mines 134
Royalty to the state in river mines, cost of 133
Royalty to the state, per cent. cost of, in one ton of 2,240 pounds—river mines 134
Running time of land mines 110, 111
Running time of river mines 132

S.

Selling phosphate in foreign markets, method of 68
Selling price (relative) in London of various Florida phosphates 68
Shipments and consumption of phosphate, United States 96–102
Shipments and consumption of South Carolina phosphate from 1867 to 1892 97
Shipments indicating the consumption of United States phosphate during 1891 101
Shipments of Florida phosphate from 1888 to 1892 99
Shipments of Florida phosphate through United States custom-houses for the years 1891 and 1892 98
Shipments of phosphate from land mines 110, 111

Page.

Shipments of phosphate from river mines 132
Shipments of phosphate, quantity and value of, in 1891 and 1892 104
Shipments of South Carolina phosphate, relative increase in the, by five-year and ten-year periods 100
Soft phosphate, analyses of........ 57
Soft phosphate, description of........ 55–58
Soft phosphate sold for consumption in Florida in 1890, 1891, and 1892, quantity and value of.. 58
South Carolina and Florida phosphate deposits, favorable location of 10
South Carolina and Florida phosphate industry, consideration of 11
South Carolina, cost of production of phosphate in—summary........ 93, 95
South Carolina, description of river mining of phosphate in 84, 85
South Carolina, discovery of phosphate in 77–82
South Carolina, growth of phosphate industry in 9
South Carolina, kinds of phosphate, machinery used, etc., in........ 83–85
South Carolina, land mining of phosphate in........ 83, 84
South Carolina phosphate fields, geology of 73–77
South Carolina, phosphate industry of 71–86
South Carolina phosphate, relative increase in the shipments of, by five-year and ten-year periods 100
South Carolina phosphate, shipments and consumption of, from 1867 to 1892 97
South Carolina rock phosphate, analyses of........ 85, 86
South Carolina, royalties paid on phosphate to, from 1870 to 1892........ 105
Superintendence and clerical labor, cost of, in one ton of 2,240 pounds—land mines 118, 119
Superintendence and clerical labor, cost of, in one ton of 2,240 pounds—river mines........ 134
Superintendence and clerical labor, cost of—land mines........ 116, 117
Superintendence and clerical labor, cost of—river mines........ 133
Superintendence and clerical labor, per cent. cost of, in one ton of 2,240 pounds—land mines.. 120, 121
Superintendence and clerical labor, per cent. cost of, in one ton of 2,240 pounds—river mines.. 134
Supplies and repairs, cost of, in one ton of 2,240 pounds—land mines 118, 119
Supplies and repairs, cost of, in one ton of 2,240 pounds—river mines 134
Supplies and repairs, cost of—land mines........ 116, 117
Supplies and repairs, cost of—river mines........ 133
Supplies and repairs, per cent. cost of, in one ton of 2,240 pounds—land mines........ 120, 121
Supplies and repairs, per cent. cost of, in one ton of 2,240 pounds—river mines........ 134

T.

Tate's shaft, a geological wonder 65, 66
Taxes, cost of, in one ton of 2,240 pounds—land mines........ 118, 119
Taxes, cost of, in one ton of 2,240 pounds—river mines........ 134
Taxes, cost of—land mines 116, 117
Taxes, cost of—river mines 133
Taxes, per cent. cost of, in one ton of 2,240 pounds—land mines........ 120, 121
Taxes, per cent. cost of, in one ton of 2,240 pounds—river mines 134
Theoretical elements of production, cost of, in one ton of 2,240 pounds—land mines........ 124, 125
Theoretical elements of production, cost of, in one ton of 2,240 pounds—river mines........ 135
Theoretical elements of production, cost of—land mines........ 122, 123
Theoretical elements of production, cost of—river mines........ 135
Theoretical elements of production, cost of, of phosphate in Florida—summary........ 92, 94
Theoretical elements of production, cost of, of phosphate in South Carolina—summary........ 93, 95
Thickness of deposit (average) in land mines 112, 113
Thickness of deposit (average) in river mines........ 132
Topography of the Florida phosphate belt 34, 35
Transportation, distance and means and cost of—land mines........ 114, 115
Transportation, distance and means and cost of—river mines........ 133
Transportation to place of free delivery, cost of, in one ton of 2,240 pounds—land mines........ 124, 125
Transportation to place of free delivery, cost of, in one ton of 2,240 pounds—river mines........ 135
Transportation to place of free delivery, cost of—land mines........ 122, 123
Transportation to place of free delivery, cost of—river mines........ 135

V.

Value and quantity of phosphate mined—land mines........ 110, 111
Value and quantity of phosphate mined—river mines 132
Value and quantity of phosphate shipments in 1891 and 1892 104
Value and quantity of soft phosphate sold for consumption in Florida in 1890, 1891, and 1892... 58
Value at mine of phosphate in the United States—summary........ 91

W.

Wages and number of employés, by occupations 106
Wages, average daily, of employés in land mines, by occupations........ 126–131
Wages, average daily, of employés in river mines, by occupations........ 136, 137
Wages [earnings], average annual, and number of employés in phosphate mining in the United States—summary 91
Wages of employés in a land pebble phosphate mine 61
Wages of employés in a plate rock phosphate mine 54
Wages of employés in a river pebble phosphate mine........ 65
Withlacoochee basin, described by Dr. Pratt 25–31
Wonder, Tate's shaft a geological........ 65, 66
Working time of land mines 110, 111
Working time of river mines........ 132